APPENDIX D

Surface Runoff Technical Materials

San Francisco Bay Area Environmental Management Plan

June 1978

This plan was prepared by the Association of Bay Area Governments with a grant and other assistance from the Environmental Protection Agency, in cooperation with Bay Area Air Pollution Control District, Metropolitan Transportation Commission, San Francisco Bay Regional Water Quality Control Board and Counties of the Bay Area with assistance of these agencies: ■ Army Corps of Engineers ■ California Air Resources Board ■ California Department of Health ■ California Department of Transportation ■ Council of Bay Area Resource Conservation Districts ■ Governor's Office of Planning and Research ■ Lawrence Berkeley Laboratory ■ Lawrence Livermore Laboratory ■ San Francisco Bay Conservation and Development Commission ■ State Water Resources Control Board ■ State Solid Waste Management Board ■ Wastewater Solids Study

ABAG

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Part I

SR/Tech Memo 1/July 76
D. Hemovich/Y. Litwin

Surface Runoff Management Plan

Preliminary Outline of Storm Water Sampling Program

Technical Memorandum No. 1
July 30, 1976

A. Introduction - The purpose of the sampling program is to obtain information on the relationship between land use and storm runoff water quality. Data from the sampling program will be used to estimate pollutant mass-emission rates from watersheds with different types of land use. This information is essential for verification of the storm water runoff model which will be used by ABAG and the counties as part of the 208 program. Because sampling budgets are small, it is imperative that the program be conducted in a manner that maximizes the usefulness of the data acquired. The following paragraphs describe the recommended approach and procedures to be used by the counties to insure this objective.

B. Watershed Selection

1. The program can be carried out most effectively by concentrating resources on a relatively small number of watersheds (i.e., one or two per county). Five to ten storm events could then be characterized at a single sampling station on each watershed.

2. Watershed selection will proceed in three stages:

    a. ABAG will review the overall data needs and suggest to counties certain land use types for monitoring (by August 31).

    b. Counties will identify one or two watersheds within their jurisdiction for monitoring based on the selection criteria shown below.

    c. ABAG will review and approve selected watersheds.

3. The following criteria should be used in the selection of sampling stations.

a. Watershed must be large enough to generate measurable flow during rainfall episodes. Wherever possible, review of historical data would be useful for assessing the expected flow quantity and quality.

b. Sampling station should have a stream gage or should be such that a gaging station can be readily installed.

c. Rainfall data should be available within watershed boundary or its close vicinity.

d. Land use type within the watershed should be fairly uniform; the land use type identified by ABAG should represent at least two-thirds of total watershed area.

e. Sampling station on the watershed must not be influenced by tidal flow, man-made diversions or obstructions, or backwater curves.

f. The watershed upstream of the sampling station should not contain point discharges of municipal or industrial waste or major nonpoint sources of pollutants inconsistent with the overall land use type (e.g., an isolated dairy in a generally suburban watershed.)

g. Sampling station must be easily and quickly accessible during rainy weather. The station should also be such that the samples can be easily collected during storm flows without excessive danger to personnel or equipment.

C. Sampling Procedure

1. The data to be collected must be useful for model verification. Because data from one county or watershed may be used in another county or watershed, ABAG is interested in insuring that proper and uniform procedures are followed in sample collection. ABAG will recommend final details of the program based on discussions with the storm water runoff model consultant. The following items should be used for general guidance in the interim.

2. All samples will be grab samples, collected, preserved, stored and transported according to Standard Methods* and other recognized procedures. ABAG will develop a detailed set of procedures for sampling with assistance from USGS and laboratories that conduct the analyses. This information will be provided to all sample collection teams and personnel involved in the sample collection program. If the samples are improperly collected, the resulting data may be meaningless.

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*American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Standard Methods for the Examination of Water and Wastewater, 12th Edition, American Public Health Association, 1965.

3. In the interim, the following will be used in the design of the sample collection program. The frequency of sampling, including the number of samples and parameters should be flexible throughout the program in order to accomodate changes in the concept of the sampling program.

   a. Stream flow must be measured at the same time that the water quality samples are collected.

   b. An estimate of 5 to 10 sampling periods per storm event is anticipated. Base flow, prior to storm occurence should be sampled to provide a background reading.

   c. More samples must be taken on the rising limb of the hydrograph rather than on the falling limb. On the rising limb, samples should be collected in time intervals not longer than fifteen minutes. For long storms sampling periods every 30 minutes on the rising limb may be sufficient after the first half-hour of the storm. On the falling limb of a long storm hydrograph, hourly intervals may be sufficient.

   d. More samples can be collected than will be analyzed. If a storm lasts several hours and samples are to be collected every 15 minutes the budget for analysis may be exceeded; therefore some modification may be used such as composite sampling or using only samples collected every half-hour. Some storms may prove to be less useful than others or data may be meaningless (due to spills, discharges, etc.) and a decision can be made to discard samples prior to analysis in order to conserve funds.

   e. Not all parameters scheduled for sampling need to be collected and analyzed for each time interval. Some may be collected only every other time for instance. A review of historical data and data collected on the first storm might show that some parameters are very constant or have a fixed relationship to other parameters and need not be collected as often on subsequent storms.

   f. Flow and temperature data should be available for every sampling period. In addition, during each sampling period, samples should be collected for analysis of five to ten of the following parameters: suspended solids, dissolved oxygen, TDS, COD, BOD, total nitrogen, total phosphorus, total coliforms, fecal coliforms, pH, alkalinity, oil and grease, lead, cadmium, copper, zinc mercury and arsenic.

4. For laboratory analyses of collected samples, the following guidance is given:

   a. Use commercial labs that are certified for bacterial and chemical analysis. Attachment A lists all the local commercial and noncommercial laboratories certified by the California Department of Health.

b. ABAG is suggesting and is willing to coordinate the selection of only two or three labs in the region to do all the sample analyses to achieve uniform results and cost savings due to volume discounts.

c. Some commercial labs are better than others even though all may be certified. Contacts at the State Department of Health have their opinions on the quality of work of different labs, which they are willing to discuss off the record.

d. Price should not be a sole consideration in choice of labs.

e. In picking a lab consideration should be given to size of professional staff, clients served and reputation.

f. Labs should be willing to be involved in scheduling of data collection so that samples can be analyzed as expeditiously as possible. They must be able to schedule workload in advance. Special arrangements may have to be made for weekends and/or evenings.

D. Organization

1. Overall organization and design of the water quality data collection program will be handled by the task force designated by the county lead agency. One person in each county should serve as the program coordinator. He will be responsible for obtaining equipment, setting schedules, designating sample collection teams, obtaining lab services, reporting results and acting as local agency contact for discussions with ABAG staff and model consultant.

2. There should be one sample collection team for each sampling station in the county. Each team should consist of two persons. In addition, alternates should be designated for each team member. Previous experience in water quality sampling is strongly recommended due to the detailed and specialized procedures required for sample collection.

3. The type of equipment needed for each team will include items such as rain gear, vehicles, sample containers, means to collect samples (possibly hand operated suction pump), tags, preservatives, storage containers (including low temperature containers), safety equipment, and data recording equipment. Some of the equipment may have to be rented or purchased if not available. Water districts, flood control districts and sewage treatment plants may be sources for loan of equipment.

4. The following procedures should be used in organizing the sample collection program:

   a. Once all teams are designated there should be at least one briefing of all persons involved in the program to insure that everyone knows assignments, procedures, techniques, etc. The briefing should include distribution of detailed assignments, sampling procedures, maps and so forth.

b. One dry run sampling program will be attempted to check mobilization, travel, equipment, procedures, etc., to get the bugs out.

c. Sample collection teams will be notified to be "on alert" during normal work day hours during rainy season. A few days before storm front hits the Bay Area, personnel will be given additional notice.

   All equipment should be rechecked.

d. If a storm occurs in the morning or early afternoon of a normal work day, the sample collection teams will be mobilized and head out to their stations in order to sample on the rising hydrograph.

e. It is essential that the sampling team arrive before the hydrograph starts to rise appreciably. Time should be allowed for travel and setting up of equipment at the sampling stations.

f. Special procedures will need to be developed for mobilizing sample collection teams should the storm hit on weekends, night or late afternoon.

E. Budget

1. The budget for each county for sample collection is approximately $8,000. This will be modified according to number of watersheds, sampling stations and parameters to be sampled.

2. An estimate for purposes of budgeting should include the following items:

   a. Organization - labor costs for program coordinator to plan and schedule program; briefings and dry run for personnel; estimated at $1,000.

   b. Equipment - costs for rental or purchase of all collection and support equipment if not loanable; handouts, maps, information items for collection teams; estimated at $750.

   c. Direct Labor - labor costs for sample collection team including travel preparation time and sampling time; estimated at 2 persons per station for 8 storms (or 4 storms and 2 stations), $10 per hour, 8 hour duration, $1,280.

   d. Lab Analyses - estimated at $125 per sample period (for 5-10 parameters), 5 sampling periods per storm, 8 storms, $5,000. This estimate is based on recent cost survey conducted by ABAG - see Attachment B.

State of California
Department of Health

Sanitation and Radiation Laboratory
2151 Berkeley Way, Berkeley 94704

Non-Public Health Laboratories Approved for Water and Waste Analysis by the California Department of Health

January 1976

COMMERCIAL LABORATORIES

COUNTY & CITY	LABORATORY	Determinations covered by approval certificate include: BIOASSAY	BACTERIOLOGICAL	CHEMICAL
ALAMEDA				
Berkeley	Engineering-Science	x	x	x
	Rudd	x	x	x
Dublin	Foremost Research		x	x
Hayward	Trace Analysis			x
Oakland	Frederiksen Engineering	x	x	x
	Uni-Research		x	
	Western		x	
CONTRA COSTA				
Concord	Lederer		x	x
Pt. San Pablo	S.F. Bay Marine Research	x	x	x
Richmond	Ray W. Hawksley	x	x	x
	LFE Environmental Analysis	x	x	x
Walnut Creek	Morrow Engineering	x	x	x
	Ultrachem	x	x	x
SAN FRANCISCO				
San Francisco	Curtis & Tompkins		x	x
	Environmental Quality	x	x	x
	Abbot A. Hanks			x
	Pacific Chemical		x	x
	Pacific Environmental	x	x	x
SAN MATEO				
Menlo Park	Cook-NUS	x	x	x
	Stanford Research	x		
Millbrae	Garratt-Callahan		x	
Redwood City	Diamond Shamrock			x
SANTA CLARA				
Los Gatos	Perry		x	
Mountain View	Testing & Controls		x	x
Palo Alto	International Nutronics		x	x
	John H. Jenks		x	x
	Metcalf & Eddy	x	x	x
	Teledyne Isotopes	x		x
San Jose	Central Medical		x	
	Emcon	x		x
	San Jose Clinical		x	
Santa Clara	FMC Environmental Eng		x	x
	Envirotest	x		x
	Stoner	x		x

COUNTY & CITY	LABORATORY	Determinations covered by approval certificate include: BIOASSAY	BACTERIOLOGICAL	CHEMICAL
SOLANO				
Vallejo	Vallejo Clinical		x	
SONOMA				
Healdsburg	Technical		x	
Santa Rosa	Brelje & Race	x	x	x
	Central Pathology		x	
	Empire Medical		x	
	Physicians Medical		x	
Sonoma	Caltest		x	x

State of California
Department of Health

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January 1976

NON-COMMERCIAL LABORATORIES

COUNTY & CITY	LABORATORY	BIOASSAY	COMP BACT	PART BACT	COMP CHEM	PART CHEM
		Determinations covered by approval certificate include:				
ALAMEDA						
Berkeley	Colgate					x
	National Canners		x		x	
	Flint-Cal Ink					x
	UCB Env Health & Safety		x			
Emeryville	Pfizer					x
Fremont	Alameda Co WD		x			
	Borden Chemical					x
Hayward	Ameron Pipe					x
	Hayward WWTP		x			x
Livermore	Alameda Co Flood Control Dist					x
	Livermore WRP			x		x
Newark	FMC					x
	Leslie Salt					x
	Morton Salt					x
	Union SD	x	x		x	
Oakland	East Bay MUD WWTP	x	x		x	
	East Bay MUD Water		x		x	
	Gerber Products		x			x
Pleasanton	General Electric Vallecitos				x	
	Kaiser Aluminum & Chemical				x	
	Pleasanton WWTP					x
	Valley Community			x		x
San Leandro	Kaiser Gypsum					x
	Kellogg					x
	San Leandro WPCP	x	x			x
San Lorenzo	Oro Loma SD		x			x
Union City	Holly Sugar					x
CONTRA COSTA						
Antioch	Antioch WTP		x			x
	Crown Zellerbach	x				x
	Fibreboard	x				x
	Kaiser Gypsum					x
	PG&E					x
Bryon	Contra Costa SD #19			x		x
Concord	Concord WWTP			x		x
	Contra Costa Co WD Bollman		x			x
Crockett	C & H Sugar	x		x		x
	Crockett Valona SD			x		x
	Virginia Chemical					x

OUNTY & CITY	LABORATORY	Determinations covered by approval certificate include: BIOASSAY	COMP BACT	PART BACT	COMP CHEM	PART CHEM
NAPA						
Deer Park	St. Helena Hosp & Health Cen		x			
Napa	Napa City Jameson Canyon WTP			x		
	Napa Co SD					x
Oakville	Mondavi Winery					x
St. Helena	St. Helena WWTP		x			x
Yountville	Veterans Home Hospital		x			
	Veterans Home WWTP					x
SAN FRANCISCO						
San Francisco	Alhambra		x			x
	Belfast Beverages					x
	PG&E Hunter's Point					x
	San Francisco WPCP:					
	North Point		x			x
	Richmond-Sunset		x			x
	Southeast		x			x
	San Francisco Rec-Parks WRP			x		
	US Navy Treasure Island WWTP					x
	SF Port Commission					x
	Caltrans Dist 04					x
AN MATEO						
Burlingame	Burlingame WWTP			x		x
Daly City	Daly City Water Div			x		x
	North San Mateo Co SD			x		x
Foster City	Estero Dist WWTP	x		x		x
Half Moon Bay	Half Moon Bay WWTP	x	x			x
Menlo Park	Menlo Park SD WWTP	x		x		x
Millbrae	Millbrae WWTP			x		x
	San Francisco WD		x		x	
Montara	Montara SD					x
Pacifica	North Coast Co WD			x		x
	Pacifica WWTP	x		x		x
Redwood City	Redwood City WWTP			x		x
	San Mateo Co Memorial Park WWTP					x
San Carlos	San Carlos-Belmont WWTP					x
SF Int Airport	San Francisco Int Airport WQCP			x		x
	United Airlines Eng Chem			x		x
San Mateo	San Mateo WQCP	x		x		x
So San Francisco	Fuller O'Brien Corp					x
	Merck & Co.					x
	South SF-San Bruno WWTP	x	x		x	
NTA CLARA						
Los Gatos	Santa Clara Valley WD		x		x	
Palo Alto	Palo Alto Regional WQCP	x	x		x	

COUNTY & CITY	LABORATORY	Determinations covered by approval certificate include: BIOASSAY	COMP BACT	PART BACT	COMP CHEM	P C
CONTRA COSTA (Cont'd)						
Hercules	Hercules	x	x			
	Gulf Oil-California			x		
Martinez	Contra Costa Co SD #7A			x		
	Industrial Tank					
	Martinez WTP		x			
	Monsanto					
	Mt. View SD			x		
	PG&E					
	Phillips Petroleum	x			x	
	Shell Oil					
	Stauffer Chemical	x				
Oakley	Oakley Co WD		x			
Pacheco	Central Contra Costa SD	x	x			
Pinole	Pinole WWTP			x		
Pittsburg	Allied Chemical					
	Dow Chemical	x	x		x	
	PG&E					
	Pittsburg Muni Water Works		x			
	Pittsburg WWTP			x		
	Shell Chemical					
	US Steel					
Pleasant Hill	Gregory Gardens County WD					
Richmond	Chevron Chemical					
	Great Western Chemical					
	Richmond WPCP			x		
	Standard Oil	x			x	
	Stauffer Chemical	x				
Rodeo	Rodeo SD			x		
	Union Oil	x	x			
San Pablo	San Pablo SD	x	x		x	
Walnut Creek	Central Contra Costa Co SD	x	x			
	Del Monte Research		x		x	
MARIN						
Corte Madera	Marin Municipal WD		x			
Greenbrae	Marin Co SD #1					
Marshall	Synanon		x			
Mill Valley	Mill Valley WPCP			x		
	Richardson Bay SD					
	Marin Co SD #6	x		x		
	North Marin Co WD		x			
San Quentin	San Quentin WWTP					
San Rafael	Las Gallinas Valley SD					
	San Rafael SD			x		
Sausalito	Sausalito-Marin City SD					
Tiburon	Marin Co SD #5					

COUNTY & CITY	LABORATORY	Determinations covered by approval certificate include: BIOASSAY	COMP BACT	PART BACT	COMP CHEM	PART CHEM
SANTA CLARA (Cont'd)						
Permanente	Kaiser Cement & Gypsum					x
San Jose	California Water Service		x		x	
	IBM					x
	San Jose-Santa Clara WPCP	x	x		x	
Sunnyvale	Lockheed Missile & Space					x
	Sunnyvale WPCP		x			x
	United Technology Center					x
SOLANO						
Benicia	Bencia Lake Herman WTP		x			
	Benicia WWTP			x		x
	Humble Oil & Refining				x	
Fairfield	Fairfield WTP			x		x
	Fairfield Suisun Sewer Dist			x		x
Travis AFB	Travis WWTP					x
Vacaville	Vacaville Sanitation Easterly			x		
Vallejo	American Canyon Co WD					x
	Mare Island WWTP			x		x
	Vallejo Water Dept		x			x
	Vallejo San & Flood Control			x		x
SONOMA						
Eldridge	Sonoma State Hospital			x		
Geyserville	Geyser Peak Winery			x		x
Petaluma	Petaluma WPCP	x		x		x
Santa Rosa	Santa Rosa WWTP Laguna			x		x
	Santa Rosa WWTP W College					x
	Sonoma Co Water Qual					x
	Sonoma Valley Co SD					x
Sebastopol	Silveira & O'Connel	x				x

ABBREVIATIONS

SD	Sanitary District or Sanitation Department
WD	Water District or Department
WPCF	Water Pollution Control Facility
WPCP	Water Pollution Control Plant
WQCP	Water Quality Control Plant
W Ren P	Water Renovation Plant
WRP	Water Reclamation Plant
WTP	Water Treatment Plant
WWCP	Wastewater Control Plant
WWTP	Wastewater Treatment Plant

Commercial Laboratories Cost Survey for Surface Runoff Water Analysis[1]

County & City	Laboratory	Phone	Certified For Bacteriological & Chemical Determinations	Brochure And/ Or Price List Available	Cost Estimate[2] for 13 Parameters*	Information Received	Comments
Alameda							
Berkeley	Engineering-Science	548-7970	Yes	Yes	185.00	7/14	----
	Rudd	548-5666	Yes	---	---	----	brochure being sent
Dublin	Foremost Research	828-1440	Yes	---	---	----	brochure being sent
Oakland	Frederiksen Engineering	465-0644	Yes	No	125.00	7/14	----
Contra Costa							
Concord	Lederer	682-6172	Yes	No	172.00	7/19	----
Pt. San Pablo	S.F. Bay Marine Research	254-5650	Yes	Yes	120.00	7/19	----
Richmond	Ray W. Hawksley	235-5780	Yes	No	289.00	7/19	----
	LFE Environmental Analysis	235-2623	Yes	Yes	150.00	7/16	----
Walnut Creek	Morrow Engineering	934-3155	Yes	No	314.00	7/19	----
	Ultrachem	935-3115	Yes	Yes	204.75	7/20	----
San Francisco							
San Francisco	Curtis & Tompkins	861-1863	Yes	Yes	182.50	7/15	----
	Environmental Quality	777-1070	Yes	No	170.50	7/14	----
	Pacific Chemical	981-2525	Yes	No	---	----	too busy at present
	Pacific Environmental	495-6627	Yes	Yes	183.00	7/16	----
San Mateo							
Menlo Park	Cook-Nus	368-3329	Yes	brochure only	132.50	7/15	----
Santa Clara							
Mountain View	Testing & Controls	967-6982	Yes	brochure only	110.00	7/19	----
Palo Alto	International Nutronics	968-2557	Yes	No	92.00	7/19	----
	John H. Jenks	326-2570	Yes	---	---	----	doesn't do water analysis
	Metcalf & Eddy	964-7106	Yes	Yes	170.00	----	too busy at present
Sonoma							
Santa Rosa	Brelje & Race	(707) 544-8807	Yes	Yes	127.00	7/16	----
Sonoma	Caltest	(707) 996-7211	Yes	Yes	152.00	7/15	----

1. This survey includes commercial labs certified by the State Department of Health to do both chemical and bacteriological analyses

2. Price quotes were given for 15 samples received at one time for the following 13 parameters: BOD, Coliform, SS, Total N, Total P, Oil and Grease, Hg, Cr, Pb, Zn, Cu, Cd, and Ar.

*Per sample

Surface Runoff Management Plan

PROCEDURES FOR REVIEW AND UPDATE OF BASE MAPS

Technical Memorandum No. 2
August 15, 1976

A. Introduction

The base maps are a set of 7-1/2 minutes USGS quadrangle maps, which combine the topographic, hydrologic, and water pollution-oriented data base for the entire EMP study area, i.e., the nine-County San Francisco Bay Region, excepting the San Francisco County, and the northern portions of Solano, Sonoma, and Marin Counties. These maps were compiled by ABAG staff to provide descriptions of: the study area and the overall surface runoff system configuration; the availability of data pertinent to the Surface Runoff Management Plan (SRMP); the sources of this data; and descriptions of the existing water quality problems. The most immediate usage of these maps is in facilitating the following:

(a) examination of a detailed layout of the hydrographic drainage system for the entire study area.

(b) assessment of water quality and streamflow data availability in each county.

(c) regional evaluation of major waste load dischargers and water quality problem areas.

(d) selection of watersheds for initial calibration and running of surface runoff water quality models.

(e) planning of the calibration/verification phase of the mathematical modeling of surface runoff water quantity and quality.

(f) designing water quality data collection programs.

The overall objective for preparing the base maps was to develop a standard reference for all the parties involved in preparation of the SRMP (i.e., ABAG, county lead agencies, and consultants). In addition, it is anticipated that the information contained in these maps may be used for the preparation of a set of maps (one for each county) in an atlas-like form which will summarize the existing data and significant results of the regional SRMP. To ensure the comprehensiveness and accuracy of the information contained in any final product of the EMP,

it is desirable that the maps be reviewed and updated. Since the counties are more familiar with their local data and problems, ABAG is soliciting county assistance in identifying errors or omissions. This Technical Memorandum deals with the description of the base maps, and recommended approaches and procedures for review of the maps by county personnel.

B. Summary of the Displayed Information

In addition to the standard topographic information, the data listed below are marked on the base maps using a combination of symbols and labels as depicted in Figure 1.

(a) watershed boundaries - each major watershed is designated by a two digit number. The subdivisions are given sequential alphabetical letter subscripts, advancing in a downstream direction (i.e., 12A, 12B, etc.)

(b) rainfall gauging stations - for each station, the following information is specified: station name, station identification number, elevation, period of record, missing years, and source of data.

(c) evaporation gauging stations - the information provided includes station name and elevation, type of pan used, and source of data.

(d) stream flow gauging stations - for each station the following information is specified: the monitoring agency and its code number, period of record, station location, time interval used (i.e., continuous, bi-weekly, etc.), and type of data collected (i.e., continuous stages, peak discharges, etc.)

(e) water quality monitoring stations - information given is similar to that in (d) above.

(f) waste load outflow locations - the information provided includes the name of the discharger, source of data, and brief description of the discharger.

(g) water quality problem areas - for each location the following information is given: the name, the source of data or information, and a brief description of the identified problem.

C. Sources of the Displayed Information

The review process may be simplified considerably if the sources of information used by ABAG staff are known and clearly understood. The following description deals with how the base maps were prepared.

(1) watershed boundaries - the delineated drainage areas were replicated from maps made available to ABAG by the U.S. Army Corps of Engineers, San Francisco District. They were originally prepared by the USGS in a study conducted for the Corps

of Engineers in May, 1960 [1]. Only drainage areas of streams tributary to the Bay between Collinsville and the Golden Gate were included. The following criteria were used in determing these drainage areas.

- o all streams at least two miles long or which have drainage areas of at least three square miles.
- o all for which that streamflow or crest-stage gauges had been maintained by the Corps of Engineers or by the USGS at that time.
- o all streams which were thought to be hydrologically significant.
- o all reservoirs at their spillways.
- o large sloughs and marshes lying at mean sea level.
- o areas in-between drainages in the above categories.

Attachment A provides drainage area figures for all the delineated basins tabulated separately by stream name and by primary basin name as given in the USGS report [1]. Since the delineated basins represent natural watersheds as identified from the topographic maps, the actual watershed bounderies in some urban or agricultural areas might be somewhat different due to man-induced drainage systems.

(2) climatologic data - the raingauges were plotted from a computerized file of DWR updated to February, 1976 [2]. The evaporation stations were plotted from DWR Bulletin 73-1 of May, 1974 [3]. The plotted location of these stations may not always be accurate because in some cases the raingauge and evaporation stations are listed in these indexes by latitude and longitude in degrees and minutes only. The actual location of a station may be as much as a half a mile away from the location shown.

(3) streamflow and water quality data - the basic sources of information were the USGS "Catalog of Information on Water Data" [4], a DWR computerized file of streamflow gauging gauging stations updated to April, 1976 [5], and a DWR computerized file of water quality monitoring stations updated to February, 1976 [6]. In addition, information was supplied by various governmental agencies and private consulting firms [7-15]. The stations listed in the USGS or DWR indices were plotted on the base maps according to the coordinates given. Whenever the coordinates did not coincide with the stream location shown on the quad map, the station was plotted at the stream point nearest the coordinates. The stations identified from other sources were plotted according to the information available and sometimes represent only approximate locations.

(4) municipal and industrial waste load outflow locations - The basic source of information was the BASSA [16] and RWQCB files [17]. These files were reviewed for all point sources with identifiable discharges for which the RWQCB have issued NPDES permits. These discharge locations were marked on the maps with arrows. Descriptions of the discharges were summarized from a variety of sources, including NPDES permits, BASSA and RWQCB files, wastewater facility project reports and EIR's. The arrows show the locations of waste outflows. Whenever the exact entry point of the wastes was unknown, the arrow was located at the most upstream portion of the storm sewer system that could be located, or at the termination of the storm sewer into a water body.

(5) water quality problem areas - The primary source of data for water quality problems was the San Francisco Bay Basin Plan [18]. In addition, information from RWQCB [17] was used to identify shellfish beds and septic tank problem areas. The septic tank problem areas were also documented in a BASSA survey of the county health departments [19]. The locations indicated as problem areas on the base maps should be considered in some cases as very general because the exact boundaries of the problem areas, such as septic tanks or shellfish beds, are difficult to determine or show without impairing the overall legibility of other data on the map. In addition, some water quality related problems such as fish kills, or constantly degraded water quality conditions cannot be pinpointed since they are rather extensive in nature.

D. General Instructions for Reviewing Base Maps

A detailed review of all the information appearing on the base maps of any given county could involve an inordinate amount of time. It is therefore suggested that from the outset, the work should be limited to a certain level of effort, for example 40-60 person hours.

The review process may be essentially carried out in three steps. The first step is a macro scale review, i.e., a comparison of the major drainage areas shown on the base map with the available hydrographic maps of the county, and examination of all the major groups of data sources known to the county personnel (for example: are all streamflow monitoring stations of the county flood control district included on the base maps). The second step should include a brief but careful examination of each quad sheet. This examination should be based on the personal knowledge of the reviewer as to the reliability of the data shown for a particular station, the accuracy of the location of waste load dischargers, various monitoring stations, and problem areas shown on the maps. In the third step, a more thorough examination and verification of the information marked on the base maps should be conducted for the selected demonstration watersheds, i.e., the watersheds for which the initial calibration and running of surface runoff water quality models will be carried out.

It is suggested that all the corrections or additions be marked in pencil on the maps supplied by ABAG. The incorrect lines or markers should be crossed out or modified as needed. A brief ex-

planatory note should be attached to each quad sheet on which corrections are made. Whenever appropriate, references to the supporting information sources should be supplied to ABAG.

E. Detailed Instructions for Reviewing Base Maps

(a) drainage area boundaries - these should be checked to eliminate gross errors. In urban areas drainage divides are likely to be inaccurate because man-made drainage systems were not accounted for. For the demonstration watersheds, all the boundaries shown on the map should be checked more carefully.

(b) rainfall and evaporation monitoring stations

- o verify the name and location of station
- o verify the period of record
- o indicate the sampling period (e.g., continuous, hourly, daily or other)
- o comment on the reliability of the data, such as the type of collection equipment used

(c) streamflow and surface water quality monitoring stations

- o verify name and location of station
- o verify parameters measured and period of record of each parameter
- o verify the sampling period (e.g., continuous, daily, monthly, seasonal, etc)
- o comment on the reliability of the data, such as the collection and analysis procedures

(d) water quality problem areas - precise locations of the indicated points are not critical. In reviewing the problem areas, emphasis should be placed on the following:

- o communities or areas that have septic tank problems which are not shown
- o areas for which septic tank problems are shown but which do not have problems
- o water quality problems that exist but are not shown, including groundwater problems
- o areas that are shown as having water quality problems but which have had those problems corrected

(e) municipal and industrial waste load dischargers - the maps should be checked for the following:

- o industries that have ceased discharging either through anti-pollution improvements, relocation or termination of business

- o new industries that have begun operation and have an identifiable discharge to other than the municipal sewerage collection system

- o locations of industrial and municipal outfalls that are grossly erroneous (in some cases, recent improvements have superseded information on the maps)

F. References

1. U.S. Geological Survey, May 1960, "Drainage Areas of Streams Tributary to San Francisco Bay," unpublished report prepared in cooperation with U.S. Army Engineer District, San Francisco.

2. State of California, Department of Water Resources, February 1976, "Climatology Data System Station Index," unpublished computer files.

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5. State of California, Department of Water Resources, April 1976, "Surface Water Data System Station Index," unpublished computer files.

6. State of California, Department of Water Resources, February 1976, "Water Data Information System (WDIS) - California Surface Water Inventory - surveillance and Monitoring," unpublished computer files.

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8. North Marin County Water District, 1975, "Water Quality Novato System #21-003," A Technical Report Prepared by William H. Nelson, Director of Water Quality.

9. East Bay Municipal Utility District, Special District One, February 1975, "Wet Weather Overflows and By-passes," A Technical Report Prepared by EBMUD staff and Water Resources Engineers, Inc.

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11. The City and County of San Francisco, November 1967, "Characterization and Treatment of Combined Sewer Overflows," A Technical Report Prepared by Engineering-Science, Inc.

12. Metcalf and Eddy, Inc., March 1971, "Storm Water Problems and Control in Sanitary Sewers," A Water Pollution Control Research Series, EPA, 11024 EQG 03/71.

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14. U.S. Geological Survey, 1974, "Availability of Data on Surface Water Quantity and Quality in the San Francisco Bay Region, California, with a Summary of Beneficial Uses and Implications for Land Use," Interpretive Reports by Joseph Goss.

15. U.S. Army Corps of Engineers, Hydrologic Engineering Center, "Annual Report on the Quality of Urban Storm Runoff Entering the San Francisco Bay," Technical Reports for FY's 1973, 1974, 1975.

16. Bay Area Sewage Services Agency, July 1976, Inventory of selected office files.

17. California Regional Water Quality Control Board, San Francisco Bay Region, July 1976, Inventory of selected office files.

18. California State Water Resources Control Board, April 1975, "Water Quality Control Plan San Francisco Bay Basin (2) - Part II," A report prepared by a consortium of Brown and Caldwell, Water Resources Engineers, Inc., and Yoder-Trotter-Orlob Associates.

19. Bay Area Sewage Services Agency, October 1975, "Bay Area Sewage Services Agency - Regional Facilities Program FY 1976/77."

ATTACHMENT A

DRAINAGE AREAS OF STREAMS TRIBUTARY TO SAN FRANCISCO BAY

Area Number	Description	Area (Square Miles)	
		Intervening	Accumulated
1	Hillside and marshland drainage from the Golden Gate Bridge to Coyote Creek at mouth. Includes Marin City and Sausalito.	3.25	
2	Coyote Creek at mouth. See separate tabulation for other Coyote Creek locations.	3.66	
3	Hillside and marshland drainage from Coyote Creek at mouth to Arroyo Corte Madera Del Presidio at mouth.	.12	
4	Arroyo Corte Madera Del Presidio at mouth on Richardson Bay. See separate tabulation for other Arroyo Corte Madera Del Presidio locations.	7.43	
5	Hillside and marshland drainage from Arroyo Corte Madera Del Presidio at mouth to the north end of Tiburon Peninsula. Includes Strawberry Point and Tiburon Peninsula.	6.72	
6	Hillside and marshland drainage south of Corte Madera Creek and north of the Tiburon Peninsula.	2.03	
7	Corte Madera Creek at Hwy. 101. Includes San Anselmo, Larkspur, Fairfax, Green Brae & Corte Madera. See separate tabulation for other Corte Madera Creek locations.	25.36	
8	Hillside and marshland drainage north of Corte Madera Creek. Bounded on the north by Southern heights ridge and on the south by Corte Madera Creek. Includes San Quentin Peninsula.	.99	
9	Narrow marshland drainage between San Quentin peninsula and San Rafael Creek at mouth.	.07	
10	San Rafael Creek at mouth. See separate tabulation for other San Rafael Creek locations.	7.03	
11	Hillside and marshland drainage between San Rafael Creek at mouth and Galinas Creek. Includes Point San Pedro and China Camp.	5.62	
12	Galinas Creek at Galinas Beach. See separate tabulation for other Galinas Creek locations.	7.43	
13	Marshland drainage between Galinas Creek and Miller Creek.	1.34	
14	Miller Creek at Northwestern Pacific Railroad tracks near St. Vincent School. See separate tabulation for other Miller Creek locations.	9.36	
15	Unnamed stream at Northern Road connecting Hwy. 101 to Hamilton Air Force Base. Includes the western part of base.	1.52	
16	Arroyo San Jose at Hwy. 101 near Ignacio. Includes Rafael Village.	5.34	
17	Hillside and marshland drainage south of Novato Creek and north of Miller Creek. Includes the greater part of Hamilton A.F.B.	9.14	
18	Novato Creek at State Hwy. 37, about 2 miles southeast of Novato. See separate tabulation for other Novato Creek locations.	31.48	
19	Hillside and marshland drainage north of Novato Creek and south of Petaluma Creek at mouth. Bounded on west by State Hwy. 37.	2.54	
20	Petaluma Creek at mouth. (San Pablo Bay). See separate tabulation for other Petaluma Creek locations.	143.19	
21	Hillside and marshland drainage from Petaluma Creek at mouth to Sonoma Creek at mouth. Includes Tubbs Island.	9.33	
22	Sonoma Creek at mouth. See separate tabulation for other Sonoma Creek locations.	152.97	
--	Total hillside tideland and basin area from the north end of the Golden Gate Bridge to and including Sonoma Creek and including 22.		435.92
23	Hillside and marshland drainage between Sonoma Creek at mouth and Napa River at mouth. Includes a narrow strip of marshland between these two points and the greater part of Mare Island.	3.96	
--	Total area from the north end of the Golden Gate Bridge to Napa River at mouth. This includes all land drainage north of S.F. Bay and West of the Napa River drainage area and excludes the napa River drainage area and all drainage east of it and north of Carquinez Strait.		439.88
24	Napa River at mouth. See separate tabulation for other Napa River locations.	425.65	
--	Total area from north end of Golden Gate Bridge to Napa River at mouth including the Napa River.		865.53
25	Hillside and marshland drainage from Napa River at mouth to a cutoff about one mile northeast of Benicia. The cutoff is the center of an unnamed stream which drains Sky Valley and flows from Lake Herman to Carquinez Strait.	9.42	
26	Unnamed stream which drains Sky Valley and Lake Herman. Cutoff is at about one mile northeast of Benicia on unnamed road. See separate tabulation.	17.89	
27	Unnamed stream at Hwy. 21 about one mile south of Cordelia. Drains part of American Canyon. Hwy. 40 passes through the center of the drainage area.	6.59	
28	Unnamed stream at Hwy. 40. Cutoff is about 200 ft. south of Southern Pacific Railroad tracks and about 3/4 mile west of Cordelia. Drains part of Jameson Canyon.	3.72	
29	Green Valley Creek at unnamed road at Cordelia. See separate tabulation for other Green Valley Creek locations.	22.42	

Area Number	Description	Area (Square Miles)	
		Intervening	Accumulated
30	Unnamed stream at Hwy. about 1/2 mile east of Cordelia and about 3/4 miles south of Hwys. 12 and 40. Includes the town of Rockville.	4.00	
31	Suisun Creek at Southern Pacific Railroad about 3 1/2 miles west of Suisun City and about one mile south of where Suisun Creek flows under Hwy. 40. See separate tabulation for other Suisun Creek locations.	49.71	
32	Ledgewood Creek at Southern Pacific Railroad tracks about 3/4 mile west of Suisun City.	16.33	
33	Hillside and marshland drainage north of cutoff along the center of an unnamed stream which drains Sky Valley and flows from Lake Herman to Carquinez Straits - and west of Suisun slough. Tributary streams are numbered 27, 28, 29, 30, 31, and 32, but this area does not include these tributary areas.	48.16	
34	Water surface area at M.S.L. of Suisun slough from Suisun City to mouth at Suisun Bay.	1.56	
35	Unnamed stream at Hwy. 12 in Fairfield. Includes the northeast corner of Fairfield.	3.87	
36	Laurel Creek at Hwy. 12 about one mile east of Fairfield.	7.19	
37	Unnamed stream at Hwy. 12 about 1 3/4 miles east of Fairfield and about 3/4 mile east of Laurel Creek at Hwy. 12.	8.28	
38	Union Creek at Hwy. 12 at Travis Air Force Base.	10.59	
39	Unnamed stream by Hwy. 12 about 2 miles east of Travis A.F.B. - between Sections 30 & 31 of Denverton Quad - Range 1 east; Township 5 north.	8.70	
40	Spring Branch at road which passes on the east side of the Potrero Hills and is about 3 miles southeast of Fairfield. This area drains the Potrero Hills which is a small, isolated mountainous area in the marshlands between Suisun slough and Montezuma slough.	2.34	
41	Hillside and marshland drainage east of Suisun slough, north and west of Montezuma slough and cutoff on the east by Denverton slough. The tributary streams which drain into this area but whose drainage areas are not included in this area are numbered 35, 36, 37, 38, 39, and 40.	42.26	
42	Total water surface area at M.S.L. of Montezuma Slough.	2.53	
43	Total land area (mostly marshland) between Montezuma Slough and San Francisco Bay. This includes Grizzly Island, Simmons Island, Dutton Island, Wheeler Island, Van Sickle Island, Chips Island, and Hammond Island.	43.76	
44	Denverton Creek at Hwy. 12 at Denverton.	2.52	
45	Unnamed stream at road. Section 17; Township 4 North; Range 1 East. Denverton Quad.	2.24	
46	Unnamed stream in Lucol Hollow at a cutoff which is about 1 mile west of Birds Landing. Section 5; Township 3 north: Range 1 east. Denverton Quad.	7.64	
47	Unnamed stream in Clank Hollow. Cutoff is in Sectión 9; Township 3 north; Range 1 east. Antioch North Quad.	1.74	
48	Hillside and marshland drainage north and east of Montezuma Slough. Tributary areas not included in this area are numbered 45, 46, and 47. Includes the town of Collinsville.	25.21	
--	Total hillside, tideland and basin area from Napa River at mouth to cutoff at Collinsville. This is the accumulated total of areas 25 to and including 48. Areas numbered 1 through 24 are not included.		348.67
--	Total hillside, tideland and basin area from the north end of the Golden Gate Bridge, to cutoff at Collinsville. This is the accumulated total of areas numbered 1 through 48. This area represents all land north of San Francisco Bay which drains into the Bay.		1214.20
49	Middle Ground Island in Suisun Bay.	.03	
50	Snay Island in Suisun Bay.	.05	
51	Freeman Island in Suisun Bay.	.16	
52	Ryer Island in Suisun Bay.	1.50	
53	Roe Island in Suisun Bay.	.41	
54	Seal Islands in Suisun Bay	.07	
--	Total North Bay. Sum of Areas 49-54	---	2.22
55	Marin Islands in San Rafael Bay.	.02	
56	Red Rock Island in San Francisco Bay about 1 1/2 miles west of Richmond.	.01	
57	Angel Island.	1.20	
58	Alcatraz Island.	.03	
59	Brooks Island in San Francisco Bay about 1/2 mile south of Richmond.	.13	
60	Yerba Buena and Treasure Islands.	.90	
61	Alameda (entire island).	7.71	
62	Government Island. Located between Alameda and the mainland.	.11	
--	Total Central Bay Sum of areas 55-62.	---	10.11
--	Total area of all islands in San Francisco Bay Area drainage. Sum of areas 49 thru 62.		12.33
	*Not including tidal islands that are cutoff from mainland only by dyked sloughs.		

Area Number	Description	Area (Square Miles) Intervening	Accumulated
63	Willow Creek at mouth. About one mile west of Pittsburg. Willow Creek flows into the Sacramento River just before the Sacramento River enters Honker Bay.	7.36	
64	Unnamed stream from Lawlor Ravine at the Sacramento Northern R.R. about 1/2 mile north of Ambrose and about 1/4 mile north at where the Sacramento R.R. separates from the Southern Pacific and Atchison, Topeka & Santa Fe railroad tracks.	1.69	
65	Unnamed stream at Atchison, Topeka & Santa Fe and Southern Pacific railroad tracks about 1/2 mile east of Shore Acres and about 1/4 mile southeast of McAvoy Boat Harbor.	2.75	
66	Mt. Diablo Creek at Sacramento Northern R.R. about 1 1/4 miles south of Port Chicago and about 1/2 mile east of Mallard Reservoir. See separate tabulation for other Diablo Creek locations.	30.40	
67	Hillside and marshland drainage between Willow Creek at mouth and Pacheco Creek. Tributary areas not included in this total are number 64, 65 and 66.	26.47	
68	Pacheco Creek at Southern Pacific R.R. about 2 miles east of Martinez. Includes entire Walnut Creek drainage area. See separate tabulation for other Pacheco Creek locations.	138.44	
69	Hillside and marshland drainage between Pacheco Creek and Arroyo del Hombre. Includes the northeast part of Martinez.	5.74	
70	Arroyo del Hombre from headwaters to cutoff at Southern Pacific R.R. on the northern outskirts of Martinez. See separate tabulation for other Arroyo del Hombre locations.	16.46	
71	Unnamed stream at Hwy. which runs through southern Crockett and central district of Valona. Approximate Lat. 33°03' ", long 122°13'15".	1.41	
72	Hillside and marshland drainage from Arroyo del Hombre to cutoff at Selby. Includes the cities of Port Costa, Crockett and Valona. Tributary area not included in this total is numbered 71.	4.76	
--	Total land drainage area from cutoff at Collinsville to cutoff at Selby. Includes areas numbered 63 thru 72.		235.48
73	Hillside and marshland drainage from cutoff at Selby to Rodeo Creek at mouth. Includes the cities of Selby and Oleum.	4.14	
74	Rodeo Creek at mouth. Includes the greater part of the City of Rodeo.	9.95	
75	Drainage area between Rodeo Creek at mouth and Refugio Creek at mouth. Includes part of the City of Rodeo.	.96	
76	Refugio Creek at mouth. About 1/2 mile north of Hercules and about 1 mile north-northeast of Pinole.	4.22	

Area Number	Description	Area (Square Miles) Intervening	Accumulated
77	Drainage area between Refugio Creek at mouth and Pinole Creek at mouth.	.63	
78	Pinole Creek at mouth. About 1/2 mile northwest of Pinole. See separate tabulation for other Pinole Creek locations.	14.89	
79	Hillside drainage between Pinole Creek at mouth and Garrity Creek at mouth.	.90	
80	Garrity Creek at mouth. 1 1/2 miles west of Pinole.	2.86	
80A	Rheem Creek at Santa Fe R.R. North end of San Pablo.	1.74	
81	Hillside and marshland drainage from Garrity Creek at mouth to San Pablo Creek. Southern cutoff is the center of San Pablo Creek. Not including Rheem Creek.	4.24	
82	San Pablo Creek at San Pablo. U.S.G.S. gauging station from 10/1/17 - 9/30/19. Lat. 37°58'00", long 122°21'24". Next to Southern Pacific R.R. tracks between San Pablo and North Richmond. See separate tabulation for other San Pablo Creek locations.	40.74	
83	Wildcat Creek at Southern Pacific R.R. tracks on the northeastern edge of North Richmond.	8.17	
84	Hillside and marshland drainage between San Pablo Creek and Cerrito Creek at mouth. Tributary area not included in this total is numbered 83. Includes the cities of Richmond and North Richmond..	18.82	
85	Cerrito Creek at mouth. About 1/2 mile northwest of Albany. Includes the City of El Cerrito.	4.38	
86	Temescal Creek at College Avenue in Oakland. At Claremont Junior High School. See separate tabulation for other Temescal Creek locations.	3.56	
87	Hillside and marshland drainage from Cerrito Creek at north to the stream that drains Lake Merritt. Includes the cities of Berkeley and Oakland. Tributary area not included in the total is numbered 86.	24.50	
88	Drainage area for Lake Merritt in Oakland. Includes the City of Piedmont.	6.36	
89	Sausal Creek at East 14th Street in Oakland between Fruitvale Avenue and 29th Avenue.	4.12	
90	Peralta Creek at East 12th Street In Oakland by Dewey School	2.28	
91	Hillside and marshland drainage from the stream that drains Lake Merritt to Arroyo Viejo. Tributary drains not included in this total are numbered 89 and 90.	11.25	
92	Arroyo Viejo at San Leandro Street in Oakland between 73rd and 75th Streets.	5.75	

Area Number	Description	Area (Square Miles)	
		Intervening	Accumulated
93	San Leandro Creek at Jones Ave. (98th Ave.) in San Leandro. See separate tabulation for other San Leandro Creek locations.	46.45	
94	Hillside and marshland drainage between Arroyo Viejo and San Lorenzo Creek at mouth. Tributary area not included in this total is number 93.	23.07	
95	San Lorenzo Creek at mouth. See separate tabulation for other San Lorenzo Creek locations.	44.72	
--	Total hillside and marshland drainage from Collinsville to and including San Lorenzo Creek at mouth. This is the sum of areas numbered 63 to and including 95.		524.20
--	Total hillside and marshland drainage from the north end of the Golden Gate Bridge to andincluding San Lorenzo Creek at mouth. This is the sum of areas numbered 1 thru 48 and 63 thru 95.		1738.40
96	Sulphur Creek at Southern Pacific R.R. about 1/2 mile north of Russell. Stream passes thru Hayward and the Hayward Municipal Airport.	4.44	
97	Smith I. Lat. 37°40'04", long 122°03'20", proposed crest stage site.	.78	
98	Smith II. Lat 37°39'52", long 122°03'17", proposed crest stage site.	[illegible]	
99	Smith III. Lat. 37°39'43", long 122°03'41", proposed crest stage site.	.46	
100B	Drainage area north of San Mateo-Hayward Bridge above the 5' contour line and between San Lorenzo and Alameda Creeks. Excludes tributary areas numbered 96, 97, 98 and 99.	7.27	
100A	Drainage areas south of San Mateo-Hayward Bridge above the 5' contour line and between San Lorenzo and Alameda Creeks.	16.97	
101B	Drainage area north of San Mateo-Hayward Bridge below the 5' contour line and between San Lorenzo and Alameda Creeks.	2.86	
101A	Drainage area south of San Mateo-Hayward Bridge below the 5' contour and between San Lorenzo and Alameda Creeks.	6.46	
102	Alameda Creek near Alvarado. U.S.G.S. gauging station. See separate tabulation for other Alameda Creek locations.	653.50	
--	Patterson Creek near Alvarado. U.S.G.S. gauging station (10/58 -). Lat 37°35'05", long 122°02'55", 1959 WSP -1635*	0.00	
103	Crandall Creek near Centerville. U.S.G.S. gauging station (1916-19). Lat. 37°34'10", long 122°01'45", 1919 - 1920 WSP -511.	.08	
104	Drainage area above the 5' contour and between Alameda Creek and Newark slough. Excludes tributary area numbered 103.	12.49	
	*Measures spill from Alameda Creeks.		
105B	Drainage area north of Dumbarton Bridge below the 5' contour and between Alameda Creek and Newark slough.	11.41	
105A	Drainage area south of Dumbarton Bridge below the 5' contour and between Alameda Creek and Newark slough.	2.30	
106	Sanjon de los Alisos at Dumbarton Rd. about 3/4 mile west of Newark. Includes the City of Centerville. This stream flows into Newark slough.	4.89	
107	Laguna Creek at Irvington. At outlet of Lagoon about 1/4 mile north of Irvington. U.S.G.S. gauging station (10/1/16 - 9/30/19). 1919 - 1920 WSP -511.	12.5	
108	Canada del Aliso at Southern Pacific R.R. about 1 1/2 miles south-southeast of Irvington.	.97	
109	Arroyo del agua Caliente at Oakland Road about 1/2 mile north of Warm Springs.	2.40	
110	Agua Fria Creek at Oakland Road about 1/4 mile north of Warm Springs.	1.79	
111	Drainage area above the 5' contour and between Newark slough and Coyote Creek. Excludes tributary areas numbered 107, 108, 109 and 110.	26.74	
112	Drainage area below the 5' contour and between Newark slough and Coyote Creek.	16.93	
113	Coyote Creek from headwaters to approximately Lat. 37°37'30", long 121°56'00". See separate tabulation for other Coyote Creek locations.	352.34	
114	Drainage area above the 5' contour and between Coyote and Guadalupe Creeks. Guadalupe Creek becomes Alviso slough.	13.96	
115	Drainage area below 5' contour and between Coyote Creek and Alviso slough.	8.88	
116	Guadalupe River at cutoff at Hwy. 101 bypass. See separate tabulation for other Guadalupe River locations.	148.20	
117	Water surface area at M.S.L. of Alviso slough.	.30	
118	Drainage area above the 5' contour between Guadalupe River and Saratoga Creek.	13.78	
119	Saratoga Creek at mouth. Mouth is at Alviso slough. See separate tabulation for other Saratoga Creek locations.	[illegible]4.43	
--	Total hillside and marshland drainage from San Lorenzo Creek at mouth (not including San Lorenzo Creek at mouth) to and including Alviso slough, its water surface area and its tributaries. This is the sum of areas numbered 96 to and including 119.		1378.00

Area Number	Description	Area (Square Miles)	
		Intervening	Accumulated
--	Total hillside and marshland drainage from the north end of the Golden Gate Bridge to an including Alviso slough, its water surface area and its tributaries. This is the sum of areas numbered 1 thru 48 and 63 thru 119.		3116.40
120	Stevens Creek at Bayshore Hwy. about 1/2 mile west of Moffett Field. See separate tabulation for other Stevens Creek locations.	25.12	
121	Permanente Creek at Bayshore Hwy. about 1 3/4 miles west of Moffett Field.	17.13	
122	Drainage area above the 5' contour and between Saratoga and Adobe Creeks. Excludes tributary areas numbered 120 and 121. Adobe Creek becomes Charleston slough.	32.18	
123	Water surface area at M.S.L. of Guadalupe River. This is to be distinguished from the Guadalupe River which flows into Alviso slough.	.30	
124	Drainage area below the 5' contour and between Alviso slough and Adobe Creek (Charleston slough). This area excludes the water surface area of Guadalupe River which is area numbered 123.	11.34	
125	Adobe Creek at Bayshore Highway about 3/4 mile east of Palo Alto.	9.88	
126	Dry Creek at Bayshore Highway about 5/8 mile east of Palo Alto.	3.45	
127	Matadero Creek at Palo Alto. U.S.G.S. gauging station (7/52 -). Lat. 37°25'10", long 122°08'10", 1957 WSP -1515.	7.24	
128	Drainage area above 5' contour and between Charleston slough and San Franciscquito Creek. Excludes areas numbered 126 and 127.	7.33	
129	Drainage area below 5' contour and between Charleston slough and San Francisquito Creek.	2.62	
130	San Francisquito Creek at Bayshore Hwy. See separate tabulation for other San Francisquito Cr. locations.	41.21	
131A	Drainage area south of Dumbarton Bridge above 5' contour and between San Francisquito Creek and Atherton Drainage Channel.	2.69	
131B	Drainage area north of Dumbarton Bridge above 5' contour and between San Francisquito Creek and Atherton Drainage Channel. (Westpoint slough).	3.85	
145	Drainage area below 5' contour between Redwood Creek and San Mateo Creek. Excludes slough areas numbered 143 and 144.	16.23	

Area Number	Description	Area (Square Miles)	
		Intervening	Accumulated
146	San Mateo Creek at mouth. See separate tabulation for other San Mateo Creek locations.	34.25	
147	Hillside drainage between San Mateo Creek at mouth and unnamed stream at mouth. Unnamed stream passes by Burlingame Country Club and flows into the Bay near the Burlingame sewage disposal plant.	5.04	
148	Unnamed stream at mouth. Stream flows by Burlingame Country Club and enters the Bay near the Burlingame sewage disposal plant.	1.98	
149	Easton Creek at El Camino Real near Broadway in Burlingame	.70	
150	Mills Creek at Southern Pacific R.R. at the northwest edge of Burlingame.	.90	
151	Unnamed stream at El Camino Real and Murchison Drive in Millbrae. (Millbrae Creek).	.62	
152	Unnamed stream at El Camino Real and Crystal Springs Road in San Bruno.	.60	
153	San Bruno Creek at El Camino Real in San Bruno next to Tanforan Race Track.	1.09	
154	Hillside and marshland drainage from unnamed stream in Burlingame (area number 148) to Colma Creek. Excludes areas numbered 149, 150, 151, 152, and 153.	10.47	
155	Colma Creek at cutoff about 800 feet east of Bayshore Hwy. See separate tabulation for other Colma Creek locations.	14.82	
156A	Hillside and marshland drainage south of Sierra Point between Colma Creek and unnamed stream at Brisbane.	2.05	
156B	Hillside and marshland drainage north of Sierra Pt., between Colma Creek and unnamed stream at Brisbane.	.33	
157	Unnamed stream at mouth. Stream is just north of the City of Brisbane.	2.55	
158	Hillside drainage from unnamed stream near Brisbane (area number 157) to the south end of the Golden Gate Bridge.	29.77	
--	Total drainage from Alviso Slough to south end of the Golden Gate Bridge. Sum of areas numbered 120 thru 158.		333.15
--	Total Bay Area drainage. From the north end of the Golden Gate Bridge clockwise around San Francisco Bay and to the south end of the Golden Gate Bridge. This is the sum of area numbered 1 thru 48 and 63 thru 158. This <u>does not</u> include islands in the Bay which are numbered <u>49 thru</u> 62. This <u>does</u> include the water surface area at M.S.L. of all significantly large sloughs.		3449.53

SR/Tech Memo 3/August 76
S. Goldman

Surface Runoff Management Plan

Demonstration Watersheds
Description And Selection Criteria

Technical Memorandum No. 3
August 31, 1976

A. Background - A major objective of the efforts to be carried out by each of the San Francisco Bay counties (except San Francisco County) is the development of a countywide surface runoff management plan. In the course of these studies, runoff problems from both urban and rural areas will be examined, although greater emphasis will be given to urban runoff as the more important source of pollution. The specific priorities for addressing the surface runoff problems in each county will be left, however, to the discretion of the individual counties. Each county is being asked to develop an approach which will address the problems characteristic of its area.

ABAG intends to provide the counties with a variety of technical assistance. The most significant type of assistance will be mathematical modeling of surface runoff water quality, whereby ABAG (through its contractor--the firm of Metcalf and Eddy) will assist the counties with training in the use of the models selected by ABAG (SWMM, QUAL II, and a newly developed Planning Model, analogous to STORM). This assistance will also include in-depth analysis of at least one watershed from each county, and considerable support in the subsequent modeling efforts to be carried out by the counties as part of their efforts in developing surface runoff management plan.

Because of time and budgetary constraints, it is unlikely that an in-depth modeling analysis can be carried out for all the watersheds of interest within each county. It is therefore suggested that the counties select one to four watersheds which will become the focus for detailed analyses. The selected watersheds should either represent typical water quality conditions of problems found within

a given county, or address some of the more specific problems, thus providing the counties with an opportunity to use this program to their greatest benefit. Since the counties share the responsibility for producing countywide surface runoff management plans, the analysis of remaining portions of each county will be accomplished by a combination of a macro approach (the Planning Model) and an extrapolation of the results from the selected watersheds.

The approach of selecting several watersheds within each county for a detailed analysis originally evolved from the question of how many watersheds could be analyzed in-depth by mathematical models within the time and budget allocated to each county. However, it quickly became apparent that the proposed approach would also facilitate three additional aspects of the county surface runoff management plans, namely:

1. storm water quality sampling program;

2. initial assessment of a variety of surface runoff control measures; and

3. in-depth analysis of the collected data on institutions and finances and on local development policies.

The storm water quality sampling program will be carried out to provide calibration data for the mathematical models and to obtain direct information for estimating pollutant mass-emission rates from watersheds with different types of land use. Because the sampling budgets are rather limited, it has become evident from the sampling cost survey conducted by ABAG (See SR/Tech Memo 1/July 76) that the sampling program will be limited to one or two sampling stations in each county. To maximize the usefulness of the data acquired, it is recommended that the sampling stations be located within the watersheds selected for the in-depth analyses.

The main objective of the selection of demonstration watersheds is for use in the mathematical models of surface runoff water quality. However, the selection of demonstration watersheds also completes part of the assessment process for the surface runoff management plan. The assessment process for surface runoff includes six distinct steps;

- o watershed delineation and selection;
- o assessment of control measure suitability;
- o assessment of direct effect and direct cost;
- o preparation of alternative plans;
- o comparison of effect and cost of alternative plans;

- assessment of alternative plans for effect on environmental, economic, social, and institutional/financial criteria.

The first three assessment steps will focus on the demonstration watersheds. The last three steps will extrapolate from the demonstration watersheds to consider countywide concerns in preparing and assessing the county surface runoff alternative plans.

The data collected on institutions and finances will provide the background information concerning the development of institutional-financial mechanisms for the implementation of the management plans. On the other hand, the data on local development policies provide information about current operating policies and policy instruments of agencies that control local development, whether by regulation, or by provision of essential services. Because of the efforts to be spent on analyzing the control measures for the selected watersheds, it is desirable to obtain for these watersheds the data on local development policies, institutions, and finances.

B. Definition Of Demonstration Watershed

A demonstration watershed is defined as a watershed selected for detailed analysis. The main emphasis will be the use of mathematical models for simulating surface runoff water quality in order to achieve the following objectives:

1. quantification of the extent and cause of existing water quality problems;

2. estimation of the extent and cause of future pollution by surface runoff; and

3. assessment of the impact on water quality of instituting various control measures.

It should be reiterated, however, that a demonstration watershed may also involve a variety of additional in-depth analyses--water quality sampling, evaluation of institutional-financial mechanisms for implementation of control measures, and examination of data on current development and other environmental policies.

C. Selection Criteria

It is anticipated each county will select from one to four demonstration watersheds for in-depth analysis. The initial list of candidate demonstration watersheds may include, however, a larger number of watersheds. The following are the major selection criteria that

should be used in selecting the demonstration watersheds.

1. Criteria related to issues primarily of local significance, including,

    a. beneficial use areas

    b. growth areas

    c. problem areas

    d. control measure testing areas

2. Criteria designed to make modeling results applicable to watersheds not modeled in detail, including,

    a. watershed size

    b. homogeneous land use

    c. types of control measures tested

3. Criteria designed to make modeling results more reliable, including,

    a. availability of streamflow data

    b. availability of water quality data

    c. availability of rainfall data

    d. suitability for water quality sampling program.

D. Discussion Of Selection Criteria

1. Beneficial uses - Does the watershed contain a stream or water body with a beneficial use identified in the Basin Plan or by the County or by a city within the County? Examples of beneficial uses include water supply, fishing, swimming and marine habitat. There are essentially two reasons for a county to select a beneficial use area for study as a demonstration watershed:

    a. If a beneficial use is already being threatened by a particular problem, or

    b. If the County wants to know what is required to protect the use in the future, e.g., to determine how much future development can be accommodated without jeopardizing the use, or what control measures will be most effective in protecting the beneficial use.

2. Growth areas - Future development will likely have an impact on water quality. If there are areas within the county likely to experience significant development over the next 25 years, it may be of interest to quantify the effects of such development on water quality so that appropriate mitigation measures can be taken.

3. Problem areas - If there is an existing water quality problem in the county--such as a low D.O. level in a stream or a contaminant in a water supply reservoir--it may be of interest to study a watershed in an area such as this to better define the problem and explore possible solutions.

4. Control measure testing areas - If the county is interested in testing a particular type of control measure, such as a retention basin in a shopping center or residential street sweeping, then it is important to select a watershed which contains land uses appropriate for testing such techniques.

5. Watershed size - If more than one watershed is selected for detailed analysis, the demonstration watersheds vary in size. It may be advisable to select watersheds which cover the range of watershed sizes typically found in the County. For example, one could be less than 4 square miles, one 4-10 square miles and one greater than 10 square miles. Such an approach would facilitate the application of modeling results to other watersheds in the County which were not analyzed in detail.

6. Homogeneous land use - It is desirable in selecting a demonstration watershed to have generally homogeneous land use within the boundaries. For example, if one demonstration watershed is rural, another one should be urban. If two of the candidate watersheds are urban, one might be predominantly residential and the other might contain a high percentage of commerical or industrial land.

7. Types of control measures tested - The objective of the present study is to evaluate a large variety of control measures. Therefore, the selected demonstration watersheds should provide a variety of conditions so that a large number of control measures can be tested.

8. Availability of streamflow data - When a mathematical model is run for a particular stream, it generates basically two sets of simulated data; one set represents the rate of flow over a specific time interval, and the other represents the concentrations of various pollutants over the same time period and for the same location. The availability of streamflow data is, therefore, important for model calibration, i.e., comparison of the simulated streamflow data with the actual measurements, and possible modification of the model's parameters to achieve a better fit in the next simulation run.

9. Availability of water quality data - These are essential for calibration of model parameters which affect accurate simulation of the various pollutants.

10. Availability of rainfall data - Rainfall is the element which drives the hydrologic system simulated by the mathematical models. Thus, it is important to have accurate measurements of precipitation. Because of the short duration of storm events, the continuous recording raingauges are of greater value than the raingauges which only record daily totals.

11. Suitability for water quality sampling - Because of the scarcity of water quality data, the sampling program carried out by the counties may provide an important source of data for model calibration and verification. It is therefore imperative that the tentatively identified demonstration watersheds also be suitable for conducting a water quality sampling program (See SR/Tech Memo 1/July 76).

SURFACE RUNOFF MANAGEMENT PLAN

COUNTY WATER QUALITY SAMPLING PROGRAMS MODIFICATIONS AND COMMENTS

TECHNICAL MEMORANDUM NO. 4

JANUARY 10, 1977

A. OBJECTIVES

Several problems associated with the current design of the monitoring program have been identified at both informal and technical advisory committee meetings. The purpose of this memorandum is to address some of these problems in more detail and to provide the county personnel with specific instructions for completion of tasks related to the monitoring program. Items considered in this memorandum are as follows:

- PROGRAM EXECUTION AND SAMPLING TECHNIQUES
- QUESTIONS AND RESPONSES CONCERNING THE MONITORING PROGRAM
  1. Bacteria as core parameters
  2. Dry weather sampling
  3. Monitoring of industrial land use types
  4. Sampling for surface runoff effects on shellfish beds
  5. Need for monitoring rain water quality
- ADDITIONS TO THE PROGRAM
- RECENT PROGRAM MODIFICATIONS
  1. De-emphasize fecal streptococci
  2. Expand heavy metal monitoring
- DATA REPORTING TO ABAG
- SUPPLEMENTAL WATERSHED DESCRIPTION

B. PROGRAM EXECUTION AND SAMPLING TECHNIQUES

While the efforts of some of the counties in obtaining monitoring data is commendable, the program can claim only partial success. As of January 4, 1977, only four of eight counties have collected water quality samples; and of these counties only Alameda and Santa Clara have successfully monitored the two major storm events for this rainy season. This indicates several problems in county organization and program execution.

- More alertness on the part of some counties in anticipating storms is required. The counties are refered to Technical Memorandum No. 1, "Preliminary Outline of Storm Water Sampling Program," items 1-4 under 'Organization'.

- Counties who have contracted their monitoring program to a consulting firm should maintain knowledge of the sampling execution. A visit by ABAG staff to one of the sampling sites on December 30th revealed improper techniques being employed. These errors could be minimized through increased county interest and concern in obtaining valid data.

- Ideally, each storm event would result in a storm runoff "representative" of the entire watershed. Nature is seldom completely cooperative and the counties should be prepared to sample storms producing less than the desired runoff--especially when preceded by a long dry period. The importance of monitoring early in the storm cannot be emphasized enough.

C. QUESTIONS AND RESPONSES CONCERNING THE MONITORING PROGRAM

In the Technical Advisory Committee meeting of December 17, 1976, several questions were raised concerning the surface runoff monitoring program. The ABAG staff appreciates these comments and recognizes the need for continual reassessment of program operation. Generally, the counties' inability to comply with these suggestions is a result of limited monitoring program funding. More detailed analysis of each suggestion is provided below

1. Why are bacteria not included as core parameters?

Response:

While bacteria are certainly not a desirable addition to our waters, perhaps there are other constituents which pose greater environmental dangers in the long term. Figures A and B[1] shown below demonstrate the time and distance scales over which bacteria affect the receiving body. The figures show that typical problems derived from bacterial contamination are very local and are quite short-term compared to other water quality problems.

Bacterial sampling is also among the most expensive tests (see P. 13 Progress Report #1) and an increase in this group of parameters would result in a de-emphasis of other needed measurements. Three counties are including bacteria as core parameters while the remaining counties are sampling bacteria on a spot basis. These data, combined with those from other studies,[2] should provide adequate information in this regard.

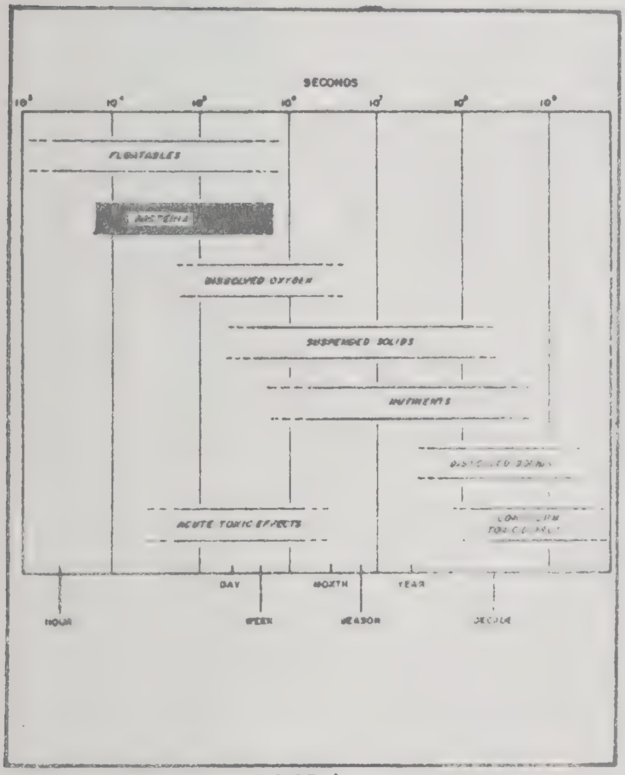

FIGURE A
TIME SCALES
STORM RUNOFF WATER QUALITY PROBLEMS

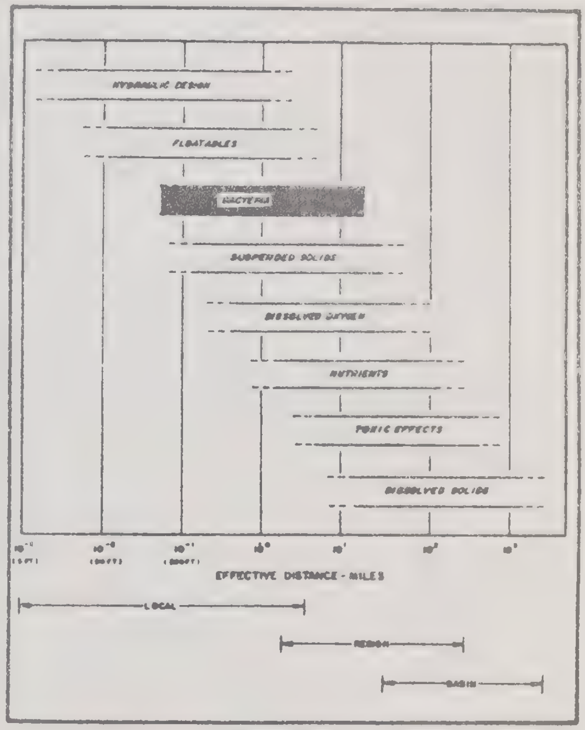

FIGURE B
SPACE SCALES
STORM RUNOFF WATER QUALITY PROBLEMS

2. Why not include dry-weather monitoring in the surface runoff monitoring program?

Response:

Most of the streams being monitored by the counties are intermittent, thus preventing any dry-weather sampling. In addition, the total dry-weather volume of flow accounts for less than 10% of the total flow draining from the nine Bay Area counties.[3]

1. Environmental Protection Agency, 1976. Areawide Assessment Procedures Manual, Vol I.

2. California State Department of Health, 1969 to present. Various investigations into the quality of receiving waters.

3 United States Geological Survey, 1971. California Streamflow Characteristics, Vol. 1, Open-File Report.

Where dry-weather flow does exist, a variety of point and non-point sources of pollution contribute to the baseflow. The point sources are by definition not to be addressed in this program. Major non-point sources consist of lawn watering, agricultural irrigation, runoff resulting from fire fighting and miscellaneous cleaning operations. These sources are so sporadic in nature that successful monitoring is quite difficult.

However, knowledge of dry-weather water quality is still desirable for providing information on the nature of pollutants present in the stream before they are flushed out by the storm event. To conserve limited monitoring funds, ABAG staff chose to rely on previous and other on-going dry-weather water quality studies in the Bay Area for this information. Data is available from studies presently being carried out by the State Water Resources Control Board, the U.S. Geological Survey and the East Bay Municipal Utility District, as well as from 47 previous surface water quality studies conducted in the Bay Area.[4]

3. Would it be possible to increase the number of industrial sites being monitored?

Response:

Since there is, at present, only one exclusively industrial site being monitored, we agree that more sites of this land-use type would be desirable. The lack of industrial monitoring sites is attributable to two reasons. The first major reason is that the final selection of watersheds for monitoring was made by each individual county. The counties were encouraged to seek watersheds which were typical of the area. While industrial sites may contribute a significant portion of storm runoff pollution, they were not chosen since they represent a relatively small land area of any single county.

The second major reason for not including more industrial sites is due to practical considerations of monitoring. Areas draining industrial locations usually lack stream gauges, which are necessary, but costly to install. Monitoring these areas can also be quite unsafe due to vehicle traffic and inaccessible sampling locations.

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4. Goss, J., 1974, "Availability of Data on Surface Water Quality and Quality in the San Francisco Bay Region, California, with a Summary of Beneficial Uses and Implications for Land Use," USGS Interpretive Report 5.

Despite these difficulties, the imbalance in land use types currently being monitored should be corrected. As we are already well into the normal rainy season, it is doubtful that this problem can be totally resolved this year. ABAG is presently preparing an interim monitoring program to sample one additional industrial site in the coming month. One or two more industrial monitoring sites could be added to the program as primary watersheds if additional funds were made available by the Environmental Management Task Force. Should funds be secured for monitoring during 1977-78, priority would be given to obtaining additional industrial surface runoff data.

4. Why can't we monitor for surface runoff effects on shellfish beds in San Francisco Bay?

Response:

It cannot be denied that bacterial and heavy metal contamination of shellfish beds in San Francisco Bay is a problem deserving attention. However, since the goal of the surface runoff program is to develop a plan to control surface runoff pollution in the Bay Area the monitoring program has focussed on identifying the nature and concentration of pollutants leaving specific land use types. Any deviation from this course of action reduces the probability of satisfactorily completing the assigned goal.

The monitoring of shellfish beds is a very different procedure than sampling streams and involves considerably greater costs. San Francisco Bay is a very complex body of water, with changing current patterns according to the Delta inflow and the tide levels. Given this situation, it is highly unlikely that monitoring one or two shellfish beds could establish a definite cause-and-effect relationship between surface water runoff and specific biological contamination.

However, the problem of shellfish contamination is not going unnoticed. In addition to numerous studies by the State Health Department, the Regional Water Quality Control Board in conjunction with the National Marine Fisheries, conducted a study of shellfish contamination in Richardson Bay from 1973-75. Currently, ABAG is devoting considerable attention to the shellfish problem under its Special Studies section. Besides compiling information on the severity of the problem, ABAG will also make recommendations on mitigating measures for incorporation into the management plan.

5. Are pollutants in the rainwater adding to the surface runoff problem?

Pollutant loads in rainwater are increased through many processes operating in an industrial society. Automobile exhausts along with numerous industrial activities continually add to the atmospheric contribution of pollutants. These materials eventually become incorporated into the surface runoff water.

While preliminary measurements in the Bay Area have revealed a reduction in the quality of precipitation, little quantitative data exists with which to assess the extent of the problem. It is apparent that more research is required to investigate the quality of precipitation to better understand surface runoff water quality. Again, the lack of funds prevent such investigations. It would require an estimated $30,000 to adequately sample rainwater quality in the San Francisco Bay Area.

D. RECENT PROGRAM MODIFICATIONS

Two recommendations were proposed by ABAG staff in the conclusions of the Summary of County Water Quality Sampling Programs, Progress Report No. 1. They are:

1. The test for fecal streptococci should be discontinued;

2. Additional funds (approximately $2,000 per county) should be made available for increased heavy metal analysis at each site.

The reader should refer to the document mentioned above for an explanation and discussion of these suggestions. The recommendation that the feca streptococci test be discontinued was based on its marginal value as a water quality parameter for the Bay Area as a whole. This does not prevent an individual county from using this test on a site-by-site analysis where its use is indicated.

With respect to the second recommendation, the additional funds requested have not yet been made available. The uncertainty of receiving these funds places concern over the amount of heavy metal sampling possible for this season. However, the counties have not sampled as many storms at this point as anticipated in the program design. Should the season continue with below-normal rainfall, it is possible that some counties could finish the year with a surplus in monitoring funds. To provide for any future developments, the counties are urged to collect additional heavy metal samples and fix them with the proper preservative. These samples can then be stored and analyzed within six months without any appreciable change in the measured constituents.

E. ADDITIONS TO THE PROGRAM

ABAG is pleased to announce that Alameda County is now monitoring the Castro Valley watershed in addition to the Glen Echo watershed. The funds for this addition were provided by the Army Corps of Engineers in a cooperative agreement secured in part through the efforts of ABAG staff. Since the Corps has monitored Castro Valley Creek for four previous years, the data obtained from this watershed is especially important. With this supplemental information on storm runoff water quality, it should be possible to assess how representative the data derived from this year's study will be. This is of special concern due to the low amount of rainfall received this year.

In addition to the information obtained from the Castro Valley watershed, ABAG will also receive data from the East Bay Municipal Utility District (EBMUD) on their San Pablo Creek study. While not a part of the Surface Runoff Program, EBMUD has expanded its list of water quality parameters to include the core parameters selected by ABAG. This intensive wet and dry-weather water quality monitoring of upper San Pablo Creek (Contra Costa County) will supply valuable data to the Surface Runoff Program.

F. DATA REPORTING TO ABAG

It is anticipated that the data collected by the counties will soon be sent to ABAG for transfer to the computer. To prevent unnecessary delay in processing this information, ABAG has provided the following form. The form consists of two pages to include all parameters. Should additional parameters be used in the monitoring program, a third page could easily be provided. The numbers 1-80 on each page correspond to the spaces on a Fortran computer card. On each page, items 1-17 are repeated for aid in identification of data cards. The key to the codes used in this data reporting is given on p.10 along with an example of a completed form. In addition to reporting of data, a form is also included for discussion and evaluation of the data. These companion forms should be filled out and returned to ABAG for each storm event monitored.

CARD #1

WATER QUALITY DATA REPORTING FORM

1. COUNTY ______________________ [1]
2. MONITORING STATION [2][3]
3. STORM NUMBER [4][5]
4. DATE OF SAMPLES [6][7][8][9][10][11]

5. DAYS SINCE LAST RAINFALL __________
6. RAINFALL FROM PREVIOUS STORM __________ INCHES
7. TIME AT START OF RUNOFF __________

CARD #	SAMPLE NUMBER	COMPOSITE	TIME	CUMMU-LATIVE RAINFALL	FLOW	TEMP	pH	D.O.	BOD_5	COD	K-N	NO_2 + NO_3	TOTAL P	S.S	V.S.S.	T.D.S.	LEAD
UNITS →				INCHES	CFS	°F	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
12	13 14 15 16	17	18 19 20 21	22 23 24 25	26 27 28 29 30	31 32 33 34	35 36 37	38 39 40 41	42 43 44 45 46	47 48 49 50 51	52 53 54 55						80
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CARD #2

WATER QUALITY DATA REPORTING FORM

1. COUNTY ______ ☐
2. MONITORING STATION ☐☐
3. STORM NUMBER ☐☐
4. DATE OF SAMPLES ☐☐☐☐☐☐

5. DAYS SINCE LAST RAINFALL ______
6. RAINFALL FROM PREVIOUS STORM ____ INCHES
7. TIME AT START OF RUNOFF ______

CARD #	SAMPLE NUMBER	COMPOSITE	TOTAL COLIFORMS	FECAL COLIFORMS	FECAL STREP	CADMIUM	CHROMIUM	MERCURY	SILVER	ARSENIC	COPPER	ZINC	TICH	CONDUCTIVITY	OIL & GREASE	MBAS
UNITS →			MPN/100 ml	MPN/100 ml	MPN/100 ml	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	umhos	mg/l	mg/l
			. E	. E	. E											
			. E	. E	. E											
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KEY TO DATA REPORTING FORM

1. County:

Alameda	1	San Mateo
Army Corps-Alameda	1	Santa Clara
Contra Costa	2	Solano
Marin	3	Sonoma
Napa	4	

2. Monitoring Station:

Alameda	
Glen Echo	01
Castro Valley	02
Army Corps-Alameda	
Alameda Creek	91
Contra Costa	
(not designated yet)	
Marin	
Sleepy Hollow	01
Halleck Creek	02
Napa	
Napa City	01
Napa Creek	02
San Mateo	
(not designated yet)	
Santa Clara	
Calabasas-lower	01
Calabasas-upper	02
Santa Clara	02
San Jose	04
Guadalupe	05
Matadero	06
Berryessa-lower	07
Berryessa-upper	08
Jones Creek	09
San Martin	10
Solano	
Green Valley	01
Sonoma	
Upper Sonoma	01

3. Storm Number

November 11, 1976	01
November 13, 1976	02
December 30, 1976 - January 2, 1977	03

Every storm thereafter which is monitored by at least one county will be assigned numbers consecutively.

4. Date of Sample mo./day/year

5. Days since last rainfall (rainfall of at least 0.10 inches in a 24-hour period).

6. Amount of previous rainfall (amount of rainfall occurring through the duration of the total storm).

7. Time at start of runoff (visible overland flow occurring within the watershed).

Notes

- If the sample was a composite, mark 'C' in column 17.

- For Card #2, the 'E' under the bacteria stands for exponent, (i.e., 560,000 = 5.6×10^5 = 5.6E5)

DISCUSSION OF THE STORM EVENT

AND

EVALUATION OF MONITORING DATA

1. General Comments On The Storm Event

   - brief discussion of severity of the storm, volume of flow, duration of storm, etc.

2. Abnormal Conditions Encountered During Storm

   - i.e. heavy oil slicks on water indicating dumping of oil during storm

3. Specific Problems Of Sampling

   - i.e. malfunction of automatic sampler in middle of storm event.

4. Interpretation of Data

   Nutrients -

   Organics -

   Solids -

   Metals -

   Bacteria -

   Other -

5. Recommendations for future storm runoff sampling

G. SUPPLEMENTAL WATERSHED DESCRIPTION

A continuing part of the monitoring aspect of the surface runoff program is to compare the data collected in this study with water quality data from other areas. However, regional differences in geology, topography, climate and other natural factors can produce substantial variations in background water quality. By compiling as much pertinent information as possible, we increase our ability to compare local watersheds with those outside the Bay Area. The information requested in the following form is considered essential by many stream investigators in differentiating one stream from another. Please complete one sheet for each monitored stream in the county and return to ABAG as quickly as possible.

Supplemental Watershed Description

1. COUNTY: ______________________________

2. STREAM: ______________________________

3. SAMPLING SITE: ______________________________

4. STATION NUMBER: __________

5. STREAM DATA:

   a. Baseflow __________

   b. Length __________

   c. Gradient __________

   d. Man-made Alterations — Yes or No

      (i) Dams __________

      (ii) Diversions __________

      (iii) Channelization __________

   If Yes, give specific details on separate sheet

6. PHYSICAL PROPERTIES OF WATERSHED:

   a. Average Rainfall __________ inches

	TYPE	% of watershed
b. Geology	__________	__________
	__________	__________
	__________	__________
c. Soils	__________	__________
	__________	__________
	__________	__________

7. LAND USE DATA:

   a. Total Area __________ Acres

	Acres	% of total area
	__________	__________
b. Single family Residential	__________	__________

	ACRES	% of total area
c. Multiple Family Residential	____	____
d. Commercial	____	____
e. Industrial	____	____
f. Open Space	____	____
(i) Forest	____	____
	TYPE	% of open space
Deciduous	____	____
Coniferous	____	____
(ii) Brush & Shrub	____	____
(iii) Grassland	____	____
(iv) Other	____	____
	____	____
		% of total area
g. Agricultural		____
		% of agric. area
(i) Row Crop	____	____
(ii) Orchard & Vineyard	____	____
(iii) Grazing	____	____

Instructions for Completing the Supplemental Watershed Description

1. County name

2. Stream (or watershed) name

3. Location of sampling site

   -- use UTM coordinates (see USGS quadrangle maps)

4. Station Number (from key to Data Reporting Form, p.10)

5. Stream data:

   a. Baseflow (use U.S.G.S. data where available. If there are no measurements, estimate baseflow if stream is not intermittent)

   b. Length of stream (measure from monitoring site to the headwaters of the longest branch)

   c. Gradient of stream (= change in elevation from headwaters of stream to elevation of monitoring site ÷ length of stream)

   d. Man-made stream alterations

      (i) Dams - include distance of dam above monitoring site, wet, or dry dam, acre/ft. of storage

      (ii) Diversions - amount and location of withdrawals, operating authority, and additions to stream and usual periods for operation

      (iii) Channelization - miles of stream bed channelized, concrete lined or not (banks included)

6. Physical Properties of Watershed

   a. Average Rainfall

   b. Geology (Maps available from U.S.G.S.)

      --provide estimate by examining up to 3 major geological formations and approximating area with accuracy (± 20%)

   c. Soils (Maps available from S.C.S.)

      --estimate as with geology

7. Land Use Data

   --much of this can be taken from previously prepared information (air photos, etc.

   --some open space data may be obtained from U.S. Forest Service

   --agricultural data may be obtained from local S.C.S. office

SURFACE RUNOFF MANAGEMENT PLAN

GUIDANCE FOR IDENTIFICATION OF SURFACE RUNOFF POLLUTION PROBLEMS

TECHNICAL MEMORANDUM NO. 5
FEBRUARY 18, 1977

A. Introduction

Control of nonpoint source pollution is a relatively new approach towards solving regional and national water pollution problems. While a large quantity of data exists for assessing point sources, the same is not true for nonpoint source pollution. This lack of knowledge about the existing problems is intensified by the complexity of the pollutant's interaction with natural stormwater systems. The task of determining relationships between land use and surface runoff quality in the Bay Area is made even more difficult by the atypical rainfall patterns occurring this year.

To aid in analyzing local surface runoff, three levels of problem identification have been adopted:

- mathematical model
- water quality monitoring
- local evaluation of problems

The first level of analysis consists of modeling. This method enables the counties and ABAG to assess the overall magnitude of pollution in the Bay from surface runoff.

Monitoring, the second level of approach assists the counties in recognizing problems within the selected watersheds. The monitoring data can be checked against

standards adopted by the State Water Quality Control Board. Where standards are not definitive, this data can be compared with information obtained from other studies.

The third level consists of subjective problem identification. Through this method, county personnel can draw on their knowledge of site-specific surface runoff problems which cause reduced water quality. This method can be made by comparing runoff data from watersheds with no problems (virgin land) or from watersheds with known problems (point sources).

The objectives of this technical memorandum are to provide the counties with the following:

- guidelines for subjective identification of surface runoff problems.

- data from other surface runoff studies for comparison with the data collected by the counties.

B. Surface Runoff Problem Identification

Surface runoff problems are the result of actions on land. Therefore, the ultimate goal of problem identification is to relate practices on land with the quality of water flowing from that land. Two methods exist for accomplishing this task:

- to study the quality of water bodies and trace this to surrounding land uses.

- to examine practices on land which have potential for resulting in polluted surface runoff.

Information for pursuing both avenues of investigation is presented in this memorandum. For purposes of simplification, surface runoff problems have been separated into two categories:

1. problems within water

2. problems on land

1. Problems Within Water

The bodies of water are the surface waters and their tributaries identified in the Basin Plan (see Appendix A). Existing and potential beneficial uses have been determined by the State Water Quality Control Board

and are also listed in Appendix A. Surface runoff related problems might be identified whenever reductions in these beneficial uses are observed.

The problems occurring in water have been divided into the following:

1. biological

2. physical

3. chemical

4. health and recreation

These are further subdivided and listed in Table 1. The categories are provided to serve as a general guide to the type of problem occurring in the water. It is apparent that there is a large amount of overlap and interaction among these categories. The county efforts should be directed towards problem identification rather than problem classification.

As evident from Appendix A, most of the surface runoff standards are not definitive. Therefore, the determination of a problem within water bodies often becomes a matter of judgement. Nevertheless, these standards are included in this technical memorandum in order to assist in problem identification. Where these standards are not sufficient for this purpose, data from other studies may be used for comparison. Some of this data is contained in Appendices B and C. The use of this data can be made in two different modes:

1. comparison with quality of surface runoff from virgin land (Table 2 summarizes national data on background concentrations for several water quality parameters)

2. comparison with point sources (Table 3 lists data from treated and untreated sewage along with surface runoff data)

It should be noted that neither method is precise. For confidence in problem identification, it is likely that both methods should be employed.

TABLE 1

PROBLEMS IN WATER

PROBLEM		Source of criteria for problem identification (page in this report) SWQCB	EPA
Biological			
a.	Algae Bloom		
b.	Excess Aquatic Weeds		
c.	Fish kills		
d.	"Rough" fish		
e.	"Sewage" fungus		
Physical			
a.	Sediment - Solids	A-5, 8	5, 6, 8. 9, B-2, B-4
b.	High Water Temperatures	A-9	
c.	Oil on surface	A-5, 9	
d.	"unnatural" color	A-5	
Chemical			
a.	Pesticides	A-9	
b.	Heavy metals	A-5	
c.	pH	A-5, 8	
d.	radioactivity	A-5, 9	
e.	low dissolved oxygen	A-8	5, 6, 9, B-2, B-5
f.	high nutrients	A-8	
g.	toxics	A-5, 9	
h.	taste	A-5	
i.	odor	A-5	
Health and Recreation			
a.	Excess turbidity	A-5, 8	
b.	high Bacterial counts	A-5, 9	5, 6, 9, B-2, B-4

TABLE 2

SUMMARY OF BACKGROUND CONCENTRATIONS FROM VIRGIN LAND

Parameter	Concentration Range (mg/1)	Comments
Nitrogen (inorganic)	0.05-0.50	highest concentrations: Iowa, Illinois, Indiana
		lowest concentrations: South, East West coasts
Phosphorus (total)	0.0 -0.20	highest concentrations: Iowa, Nebraska, Dakotas
		lowest concentrations: South, East, West coasts
BOD_5	0.50-[illegible].0	highest concentrations: Iowa, Illinois
		lowest concentrations: South, East West coasts
Coliform (total) (MPN/100ml)	100-2,000	highest concentrations: west of Mississippi River
		lowest concentrations: Northeast, Southwest
Sediment (TSS)	2-[illegible]	highest concentrations: Montana, South Dakota, Nebraska
		lowest concentrations: East, West coasts

Source: EPA, 1976, <u>Areawide Assessment Procedures Manual, Vol. I</u>

TABLE 3

CHARACTERISTICS OF NONPOINT POLLUTION COMPARED WITH MUNICIPAL SEWAGE[a]
(mg/l)

	Total solids		Susp solids		BOD		COD		NO_3-N		Total N		Total P		
	Mean[b]	Range	Mean[b]	Range	Mean[b]	Range	Mean[b]	Range	Mean[b]	Range	Mean[b]	Range	Mean[b]	Range	Ref
Municipal sewage															
typical untreated			200	100-350	200	100-300	500	250-750			40		10		10
typical treated															
primary			80	40-120	135	70-200	330	165-500			35		7.5		10
secondary			15	10-30	25	15-45	55	25-80			30		5.0		10
General characteristics															
precipitation				11-13		12-13		9-16		0.14-1.1		1.2-1.3		.02-.04	12
forested land										0.1-1.3		0.3-1.8		.01-.11	12
agricultural															
cropland					7		80		0.4		9			.02-1.7	12
urban land															
drainage		194-8620		5-7340		12-160		85-110			3			.2-1.1	12
animal feedlot runoff						1000-11000		3100-41000		10-23		920-2100		290-360	12
Individual studies															
Kansas beef cattle feedlot		10000-25000				1000-11000		4000-40000				200-450[c]			12
Waynesboro, VA forested (site 2)				15-311				24-52				1.05-1.68[c]		0-0.33	14
Durham, N.C. urban (Bryan study)	2730	274-13800			14.5	2-232	179	40-600					.58[d]	.15-2.5[d]	68
Durham, N.C. urban (Colston study)	1440	194-8620[l]	1223	27-7340[l]			170	20-1042			0.96[c]	.1-11.6[c]	.82	.2-16	8
Cincinnati, Ohio urban			227	5-1200	17	1-173	111	20-610					1.1[d]	.02-7.3[d]	2
Coshocton, Ohio rural			313	5-2074	7	.5-23	79	30-159					1.7[d]	.25-3.3[d]	2
Seattle, WA urban industrial SS3 site	140[e]		80		19		95		0.83			2.91[f]	.32[g]		72
Seattle, WA urban commercial CBD site	303[e]		190		22		66		0.72			2.82[f]	.87[g]		72
Tulsa, OK[h] urban mixed land uses	545	199-2242	367	84-2052	11.8	8-18	85.5	42-138			.85[i]	.36-1.48[i]	1.15[i]	.54-3.49[j]	10
Madison, WI urban residential	280								0.60		4.55[k]		.98		71
Eastern South Dakota agriculture runoff															
cultivated (rain)	1241		1021				148		1.5		4.1[k]		1.05		60
cultivated (snow)	187		51				49		1.0		3.1[k]		0.44		60
pasture (snow)	150		18				69		0.9		4.2[k]		0.67		60
grassland (snow)	134		42				62		0.8		3.6[k]		0.43		

a. Data presented here are for general comparison only. Since different sampling methods, number of samples, and other procedures were used, the reader should consult the references before using the data for specific planning purposes.
b. Individual values may apply to average or median. Check cited reference for clarification.
c. Total Kjeldahl Nitrogen, mg/l N
d. Total phosphate, mg/l P
e. Suspended plus settleable solids.
f. Sum of organic, ammonia, nitrite, and nitrate as mg/l N.
g. Hydrolyzable and ortho as mg/l P.
h. Values refer to the mean and range of mean values for 15 test areas.
i. Organic Kjeldahl nitrogen.
j. Only soluble orthophosphate.
k. Sum of organic, ammonia, and nitrate as mg/l N.
l. Range of values reported below.

Source: EPA, 1976, Modeling Nonpoint Pollution from the Land Surface

2. Problems on Land

Where possible, surface runoff problems are categorized onthe basis of land use. Existing and potential problems should be addressed. The following list of land-use activities and existing conditions on land provides an indication of potential problems. This list is presented as a guide and is not intended to be a complete survey of potential problems. It is anticipated that county personnel will be able to expand this list due to their familiarity with local conditions.

1. Agriculture

   a. tilling next to stream
   b. tilling on steep slopes
   c. land overgrazed
   d. animals with direct access to stream (streambank not fenced)
   e. farms without waste management plans

2. Urban

   a. streets contaning dirt and debris
   b. parking lots without infiltration facilities
   c. large gardens or lawns directly bordering street or sidewalk

3. Forestry, Mining, Open Space

   a. surface mining
   b. landfill sites with surface runoff
   c. logging operations
   d. vegetation destroyed by fire

4. Roads

   a. steep road-cuts
   b. unvegetated road-cuts
   c. significant portion of road bordering streams
   d. road surface in disrepair
   e. large number of unpaved roads

5. Problems common to all land uses

   a. gully formation
   b. streambank vegetation reduced or absent
   c. construction sites lacking erosion control
   e. streambank erosion

An indication of the magnitude of various activities on surface erosion is listed in Table 4.

TABLE 4

SOME REPORTED QUANTITATIVE EFFECT OF
MAN'S ACTIVITIES ON SURFACE RUNOFF

Initial status	disturbance	Magnitude of impact by the specific disturbance a/	Reference
Forestland	Planting row crops	100-1,000	Brown (2)
Grassland	Planting row crops	20-100	Brown (2)
Forestland	Building logging roads	220	Megahan (3)
Forestland	Woodcutting and skidding	1.6	Megahan (3)
Forestland	Fire	7-1,500	Ralston and Hatchell(4)
Forestland	Mining	1,000	Collier et al. (5)
Row crop	Construction	10	USDA/SCS (6)
Pastureland	Construction	200	USDA/SCS (6)
Forestland	Construction	2,000	USDA/SCS (6)

a/ Relative magnitude of surface erosion from disturbed surface, assuming "1" for the initial status. The first row of the table, for example, indicates that transforming a forestland into row crops will increase surface erosion 100 to 1,000 times.

Source: EPA, 1976, Areawide Assessment Procedures Manual, Vol. I

Loading rates from different land uses are presented in Table 5. As with runoff from undisturbed land uses, loading rates from various types of disturbed land uses exhibit a wide range of values.

TABLE 5

RUNOFF AREAL LOADING RATE - POUNDS/SQUARE MILE/DAY
(Average Range)

Land Use	Total Nitrogen	Total Phosphorus	BOD_5	TSS	Total Coliform
Agriculture	15 (1.9-58)	1.0 (0.05-3.9)	40 (6.3-57)	2,500 (449-6,594)	-
Forest	4 (1.3-16)	0.25 (0.01-1.4)	8 (6.3-11)	400 (71-620)	-
Pasture	8 (3.9-13.3)	0.5 (0.4-1.0)	17 (9.4-27)	670 (19-1,320)	-
Feedlots	1,700 (1,080-2,290)	370 (200-610)	-	-	-
Landfill	1,250 (50-2,500)	-	15,000 (80-33,100)	-	-
Urban	8 (3.3-28)	1.3 (0.4-7.9)	70 (20-129)	3,400 (306-7,526)	1,000 (1,000-24,000)

Source: EPA, 1976, Areawide Assessment Procedures Manual, Vol. I.

APPENDIX A

Beneficial Uses of Surface Waters

Water Quality Criteria

Water Quality Objectives

from the

Water Quality Control Plan

San Francisco Bay Basin

1975

State Water Resources Control Board
Regional Water Quality Control Board

San Francisco Bay Region (2)

TABLE 6

Existing and Potential Beneficial Uses of Surface Waters

	SURFACE WATERS	MUN	AGR	IND	PROC	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL
1	Merced Lake	○									●			●			●					
2	Crystal Springs Lakes	●									●		●	●	○		●	●				
3	San Mateo Creek						●			○	○			○			●	●				
4	Pilarcitos Lake	●									○			●	○		●	●				
5	Pilarcitos Creek	●	●							○	○			●			●	●		●	●	
6	San Andreas Lake	●									●		●	●	○		●	●				
7	San Vicente Creek		●							○	○			●			●	●		●	●	
8	Denniston Creek		●							●	●		●	●			●	●		●	●	
9	Frenchmans Creek		●							●	●			●			●	●		●	●	
10	Purisima Creek		●							●	●			●			●	●		●	●	
11	Lobitas Creek		●							●	●			●	○		●	●		●	●	
12	Tunitas Creek		●							○	○			●	○		●	●		●	●	
13	San Gregorio Creek		●							●	●		●	●			●	●		●	●	
14	Pescadero Creek		●							●	●			●	○		●	●		●	●	
15	Searsville Lake		●							●	●		●	●			●					
16	Felt Lake		●							●	●		●				●					
17	San Francisquito Creek									○	○		●	●			●			●	●	
18	Stevens Creek Reservoir	●				●					●		●	●			●			●	●	
19	Stevens Creek						●			●	●		●	●			●			●	○	
20	Calero Reservoir	●				●				●	●		●				●					
21	Almaden Reservoir	●				●				●	●		●				●					
22	Guadalupe Reservoir	●				●				○	○		●				●					
23	Lake Elsman	●									○			●			●					
24	Campbell Percolation Ponds					●							●	●			●					
25	Lexington Reservoir	●								●	●		●	●			●					
26	Vasona Reservoir					●				●	●		●	●			●					
27	Cotton Wood Lake									●	●		●	●			●					
28	Los Gatos Creek	●				●	●				○			●			●			○	○	
29	Sandy Wool Lake										●		●	●			●					
30	Guadalupe River									○	●		●				●			○	○	
31	San Felipe Creek									○	○		●	○			●					
32	Coyote Reservoir	●	●							○	○		●	●			●					
33	Anderson Reservoir	●				●				●	●		●	●			●					
34	Cherry Flat Reservoir	●	●							○	○		●				●				●	
35	Coyote Creek									○	●		●	●			●	●		●	●	
36	Arroyo De La Laguna[1]					●				●	●		○	○			●			●	●	
37	Shadow Cliffs Reservoir									●	●		●	●			●					
38	Arroyo Del Valle[1]	●				●				○	○			●			●			○		
39	Del Valle Reservoir	●								●	●		●	●			●					
40	Alameda Creek		●			●				●	●		●	●			●			○	○	
41	Elizabeth Lake										●		●	●			●					
42	Arroyo Hondo[1]	●					●			●	●		●	●			●				●	
43	Calaveras Reservoir	●									○		●	○			●					
44	San Antonio Reservoir	●									○		●	●			●					
45	Cull Canyon Reservoir									●	●		●	○			●					
46	San Lorenzo Creek[1]									●	●		●	●			●			●	●	
47	San Leandro Reservoir	●									○		●	●			●					
48	Lake Chabot	●									●		●	●			●					
49	San Leandro Creek						●			○	○		○	●			●			○	○	
50	Lake Temescal									●	●		●				●					
51	Lake Merritt									●	●		●	●			●					
52	Briones Reservoir	●								○	○		●	○			●					
53	San Pablo Reservoir	●								●	●		●	●			●					
54	Lafayette Reservoir	●								●	●		●	●			●					
55	Pinole Creek									○	○		●	●			●			●	●	
56	Walnut Creek[1]									○	○		●	●			●					
57	Mallard Reservoir[2]	●	●	●	●						○		●				●					
58	Marsh Creek									○	○		●				●	●				
59	Marsh Creek Reservoir									○	○		●				●	●				
60	Contra Loma Reservoir[2]	●	●	●	●						●		●	●			●					
61	Lake Curry	●									○		●				●					
62	Lake Madigan	●	●								●		●	●			●					

TABLE 6

Existing and potential Beneficial Uses of Surface Waters (continued)

	SURFACE WATERS	MUN	AGR	IND	PROC	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL
63	Lake Frey	●									●		●				●					
64	Suisun Creek									○	○		●	●	○		●			●	●	
65	Suisun Slough									●	●		●		○		●					
66	Montezuma Slough									●	●		●		○		●	●				
67	Lake Herman	●									○		●	●			●					
68	Chiles Creek	●					●			○	○		●	●			●					
69	Sage Creek	●					●			○	○		●	●			●					
70	Lake Hennessey	●									●		●	●			●				●	
71	Conn Creek	●					●			●	●			●			●			●	●	
72	Rector Reservoir	●									●		●	●			●					
73	Milliken Reservoir	●									○		●				●					
74	Lake Marie	●	●							○	○		○				●					
75	Lake Chabot	●	●							●	●		●	●			●					
76	Dry Creek	●	●							●	●			●	○		●			●	●	
77	York Creek									○	○			●			●			●	●	
78	Napa River	●	●					●		●	●		●	●	○		●	●		●	●	
79	Sonoma Creek									●	●		●	●	○		●	●		●	●	
80	Petaluma River							●		●	●		●	●	○		●	●		●	●	
81	San Antonio Creek									○	○		●	●	○		●			○	○	
82	Stafford Lake	●									●		●	○			●					
83	Novato Creek	●								○	○		○	○			●			○	○	
84	Rodeo Lagoon									●	●			●			●					
85	Miller Creek									○	○		●	●			●	●		○	○	
86	Lake Lagunitas	●									●		●	●			●					
87	Bon Tempe Lake	●									●		●	●			●					
88	Alpine Lake	●									●		●	●			●					
89	Kent Lake	●									●		●	●			●					
90	Lagunitas Creek									●	●			●	○		●	●		●	●	
91	Phoenix Lake	●									○		●	●			●					
92	Nicasio Creek	●					●			●	●			●			●			●	●	
93	Nicasio Reservoir	●					●				○		●				●					
94	Olema Creek									●	●			●			●			●	●	
95	Walker Creek									○	○			●	○		●	●		●	●	
96	Crystal Lake									○	○		●				●					
97	Pacific Ocean			●				●		●	●	●			●		●	●	●	●	●	●
98	South Bay			●				●		●	●	●			●		●	●	●	●	○	●
99	Lower Bay			●				●		●	●	●			○		●	●	●	●	○	●
100	Central Bay			●	●			●		●	●	●			○		●	●	●	●	●	●
101	San Pablo Bay			●				●		●	●	●			○		●	●	●	●	●	●
102	Suisun Bay & Lower San Joaquin			●	●			●		●	●	●			○		●	●	●	●	●	
103	Delta			●	●			●		●	●	●	●		○		●	●		●	●	
104	Bolinas Lagoon									●	●	●			●		●	●	●	●	●	●
105	Drakes Estero									●	●	●			●		●	●	●		●	●
106	Limantour Estero									●	●	●			●		●	●	●		●	●
107	Tomales Bay									●	●	●			●		●	●	●	●	●	●
108	San Pedro Creek										●		●	●			●			●	●	
109	Pomponio Creek		●							○	●			●			●			●	●	
110	Corte Madera Creek									○	●			●			●	●				
111	Old Mill Creek										●			●			●					
112	Pine Gulch Creek	●									●			●			●			●	●	
113	Kimball Reservoir	●									○		●				●					

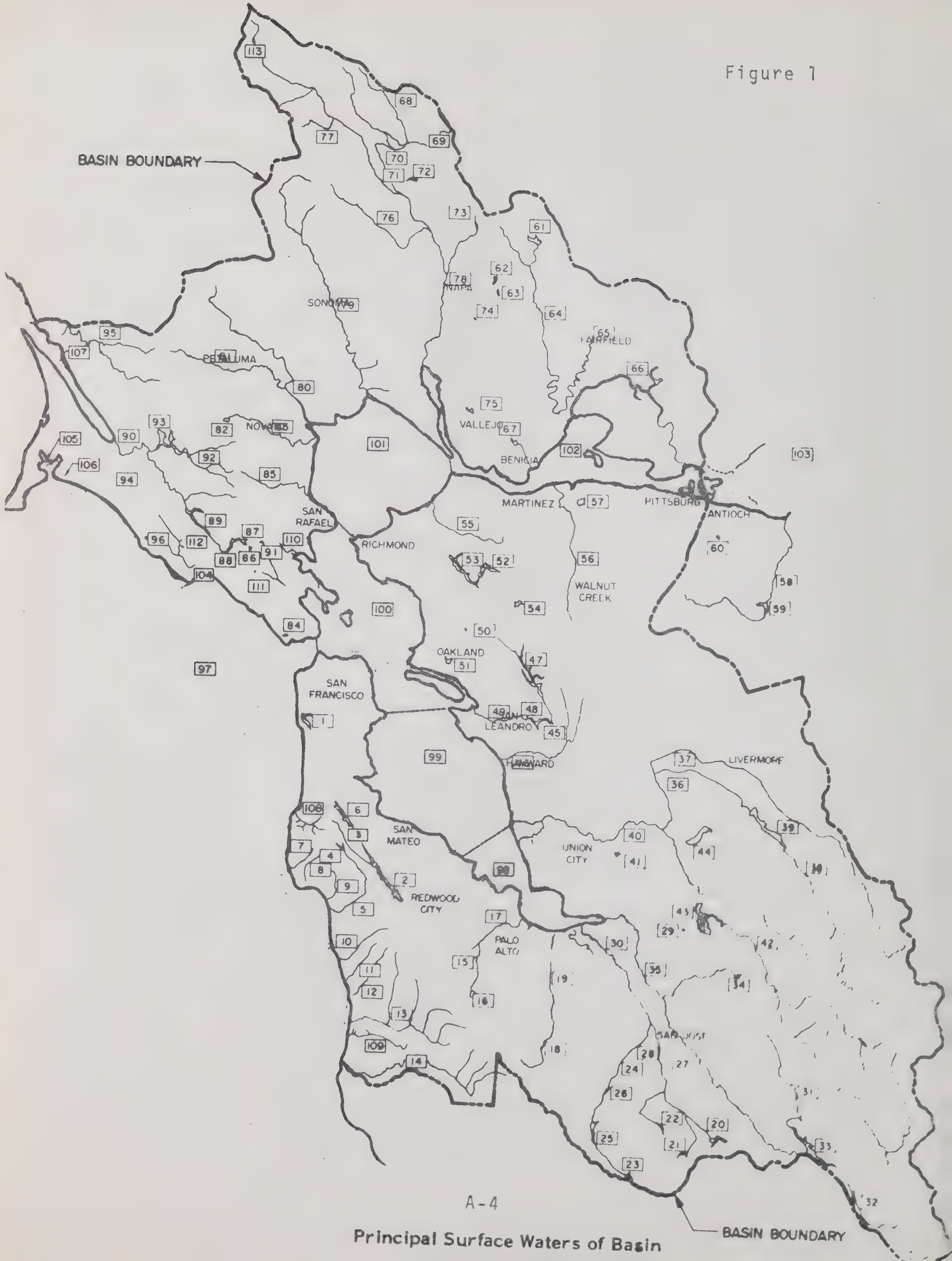
NOTES:

1. Includes Upstream Tributaries.
2. Offstream Reservoir

○ Potential Beneficial Use.

● Existing Beneficial Use.

Figure 1



Principal Surface Waters of Basin

TABLE 7

Water Quality Criteria for Beneficial Uses[a]

Parameter	MUN	AGR
sical		
Color (units)	15/-	-
dor (number)	3/-	-
emperature	-	-
urbidity (JTU)	5/-	-
uspended solids (mg/l)	-	-
ransparency (feet)[b]	-	-
ganic constituents		
otal alkalinity (mg/l)	-	-
luminum (mg/l)	-	5/20
rsenic (mg/l)	-	.1/2.0[c]
mmonia (mg/l)[d]	-	-
arium (mg/l)	1.0	-
erylium (mg/l)	.1/.5	-
oron (mg/l)	1.0	0.5/2-10
hloride (mg/l)	250/1,000	70/300-1,000
hlorine (mg/l)[e]	-	
admium (mg/l)	.01	.01/.05
hromium (mg/l)	.05	.10/1.0
obalt	-	-
arbon dioxide (mg/l)	-	-
opper (mg/l)	1.0/-	0.2/5.0
yanide (mg/l)	.01/0.2	-
luoride (mg/l)	0.8-1.7	1.0/15.0[c]
aCO_3 (mg/l)	500/-	-
on (mg/l)	0.3	5.0/20.0
ead (mg/l)	0.05	5.0/10.0
ithium (mg/l)	-	2.5
anganese (mg/l)	0.05/-	0.2/10.0
ercury (mg/l)	0.005	-
olybdenum	-	0.01/0.05
ickel (mg/l)	-	0.2/2.0
$O_3 + NO_2$ (mg/l as N)	10	-
H (units	6.0-8.5	[illegible] 4.5-9.0
elenium (mg/l)	0.01	0.02

Parameter	MUN	AGR
Inorganic constituents		
Silver (mg/l)	0.05	-
Sodium absorption ratio	-	4.0/10-20
Sulfate (mg/l)	250/500	-
Sulfite (mg/l)	-	-
TDS (mg/l)	500/1,500	-
EC (mhos)	-	-
Uranyl ion (mg/l)	5	-
Vanadium (mg/l)	-	0.10/1.0
Zinc (mg/l)	5/-	2.0/10.0
Organic constituents		
MBAS (mg/l)	0.05/0.5	-
Oil and grease (mg/l)	f	-
Phenols (mg/l)	0.001/-	
PCB's (mg/l)	-	-
Phthalate esters (mg/l)	-	-
ABS (mg/l)	-	-
Carbon alcohol extract (mg/l)	3	-
Carbon chloroform extract (mg/l)	0.15	-
COD	-	-
LAS	-	-
Biological properties		
Total coliform)per 100 ml)	100/10,000	5,000/-
Fecal coliform (per 100 ml)	20/2,000	1,000/-
Dissolved oxygen (mg/l)	-	-
Radioactivity		
Gross beta (pc/l)	1,000	1,000
Radium 226 (pc/l)	3	3
Strontium 90 (pc/l)	10	10

here two values appear (e.g., a/b), the first number represents a threshold concentration and the second represents a limiting oncentration. All single numbers represent limiting concentrations. Limiting concentrations are suggested as 90 percentile limits, ot to be violated by controllable factors more than 10 percent of the time.

s measured by Secchi disc or expressed as percent light transmittance at prescribed depth.

oncentrations for water used by livestock are more stringent. They are arsenic 0.05/1.0 and fluoride 1.0/5.0.

mmonia, expressed as undissociated NH_3OH.

esidual chlorine.

rtually absent.

Beneficial Uses

Establishing beneficial uses of surface and groundwaters to be protected serves as an initial step in a basin planning process. Once beneficial water uses are identified, compatible water quality objectives are formulated as well as the level of treatment necessary to maintain objectives and assure continuance of beneficial uses.

More than 100 individual receiving water bodies were studied in the planning process, representing the most comprehensive evaluation of beneficial uses in San Francisco Bay Basin to date. Inclusion of these water bodies and identification of beneficial uses was based on the knowledge and experience of the environmental study team as well as information obtained from the California Department of Fish and Game, the Department of Health and the Regional Board. Public comments received through workshop sessions early in the planning process were also incorporated in the final list of existing and potential beneficial uses.

Modifications, largely administrative in nature, to the list of beneficial uses result from the State Board's adoption of new designations which have been recommended for uniform statewide consideration of beneficial uses. Standard designations for beneficial uses for surface waters and groundwaters, as defined below, are applicable throughout California:

Municipal and Domestic Supply (MUN) — Includes usual uses in community or military water systems and domestic uses from individual water systems.

Agricultural Supply (AGR) — Includes crops, orchard and pasture irrigation, stock watering, support of vegetation for range grazing and all uses in support of farming and ranching operations.

Industrial Process Supply (PROC) — Includes process water supply and all uses related to the manufacturing of products.

Industrial Service Supply (IND) — Includes uses that do not depend primarily on water quality such as mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.

Groundwater Recharge (GWR) — Natural or artificial recharge for future extraction for beneficial uses and to maintain salt balance or halt salt water intrustion into freshwater aquifers.

Freshwater Replenishment (FRSH) — Provides a source of freshwater for replenishment of inland lakes and streams of varying salinities.

Navigation (NAV) — Includes commercial and naval shipping.

Hydropower Generation (POW) — Used for hydropower generation.

Water Contact Recreation (REC-1) — Includes all recreational uses involving actual body contact with water, such as swimming, wading, water skiing, skin diving, surfing, sport fishing, uses in therapeutic spas, and other uses where ingestion of water is reasonably possible.

Non-Contact Water Recreation (REC-2) — recreational uses that involve the presence of water but do not require contact with water, such as picnicking, sunbathing, hiking, beachcombing, camping, pleasure boating, tidepool and marine life study, hunting and aesthetic enjoyment in conjunction with the above activities as well as sightseeing.

Ocean Commercial and Sport Fishing (COMM) — The commercial collection of various types of fish and shellfish, including those taken for bait purposes, and sport fishing in oceans, bays, estuaries and similar nonfreshwater areas.

Warm Freshwater Habitat (WARM) — Provides a warm water habitat to sustain aquatic resources associated with a warm water environment.

Cold Freshwater Habitat (COLD) — Provides a cold water habitat to sustain aquatic resources associated with a cold water environment.

Preservation of Areas of Special Biological Significance (ASBS) — Areas of special biological significance are those areas designated by the State Water Resources Control Board as requiring protection of species or biological communities to the extent that alteration of natural water quality does not occur.

Saline Water Habitat (SAL) — Provides an inland saline water habitat for aquatic life resources. Soda Lake in the Central Coastal Basin is a saline habitat typical of desert lakes in inland sinks.

Wildlife Habitat (WILD) — Provides a water supply and vegetative habitat for the maintenance of wildlife.

Preservation of Rare and Endangered Species (RARE) — Provides an aquatic habitat necessary, at least in part, for the survival of certain species established as being rare and endangered species.

Marine Habitat (MAR) — Provides for the preservation of the marine ecosystem including the propagation and sustenance of fish, shellfish, marine mammals, waterfowl and vegetation such as kelp.

Fish Migration (MIGR) — Provides a migration route and temporary aquatic environment for anadromous or other fish species.

Fish Spawning (SPWN) — Provides a high quality aquatic habitat especially suitable for fish spawning.

Shellfish Harvesting (SHELL) — The collection of shellfish such as clams, oysters, abalone, shrimp, crab and lobster for either commercial or sport purposes.

State policy for water quality control in California is directed toward achieving the highest water quality consistent with maximum benefit to the people of the State. In keeping with this policy, all water resources must be protected from pollution and impairment that might occur as the result of waste discharge. Beneficial uses of surface waters, groundwaters, and coastal waters serve as a basis for establishing water quality objectives and discharge prohibitions to achieve this goal.

The list of beneficial uses in Table 6 is considered an accurate reflection of beneficial use demands on Basin water resources. Anticipated future beneficial uses of waters in the Basin are also included, although they may vary for a given water body depending upon future population demands, land use and water resource developments.

Water Quality Objectives

The establishment of water quality objectives, as with other aspects of water quality control planning, has become more complex in recent years because of increasing levels of protection demanded, largely as a result of increased public awareness of the benefits associated with a clean and healthy environment. Few uses can be made of natural waters without some impairment in quality and, as a consequence, impairment of its value for subsequent use. From this standpoint, criteria and objectives should be more than a list of values representing maximum limits for various impurities. More importantly, they should include statements describing appropriate water quality for each use, permitting goals (objectives) to be established for individual water uses.

For each water use, a set of water quality criteria is set forth; from these, water quality objectives have been determined. Such objectives describe the level of water quality which should exist at all times. In establishing relevant objectives, consideration must be given to the expected water uses, any adverse effects of not attaining the established objectives, the capability of controlling water quality to permit all expected uses, and the administrative and institutional aspects of water quality control. Water quality resulting from attainment of the established objectives should be sufficiently high to insure protection for all designated current and future beneficial uses.

Water quality objectives selected for the protection of beneficial uses were developed from data reviewed during the basin planning process and from the literature including published and unpublished reports. Recommendations from the State and Regional Board staffs, the University of California Board of Consultants, the Agricultural Extension Service, and the Departments of Water Resources, Health and Fish and Game of the State of California were also considered. As new information becomes available, the Regional Board will review the appropriateness of the objectives contained here.

These objectives will be subject to public hearing at least once during each three-year period following adoption of this plan for the purpose of review and modification as appropriate.

In general, the recommended objectives are intended to govern the concentration of pollutant constituents in the main water mass. Obviously, the same requirements cannot be applied at or immediately adjacent to submerged effluent discharge structures. Allowable zones of dilution within which higher concentrations will be tolerated should be defined for each discharge at the time discharge permits are drafted.

The following water quality objectives shall apply for the protection of beneficial use and aesthetic enjoyment of all inland surface waters, enclosed bays and estuaries of the Basin. Both the State Board's "Thermal Plan" which sets forth objectives for temperature in surface waters of the State and "Water Quality Control Policy for Enclosed Bays and Estuaries of California" are applicable to all surface waters inland from the Golden Gate in the Bay Basin.

pH. The pH shall not be depressed below 6.5 nor raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.2 units in waters with designated marine (MAR) beneficial uses nor 0.5 units in fresh waters with designated COLD or WARM beneficial uses.

Dissolved Oxygen. All waters designated as aquatic life habitat shall be maintained at protection level B, unless otherwise designated.

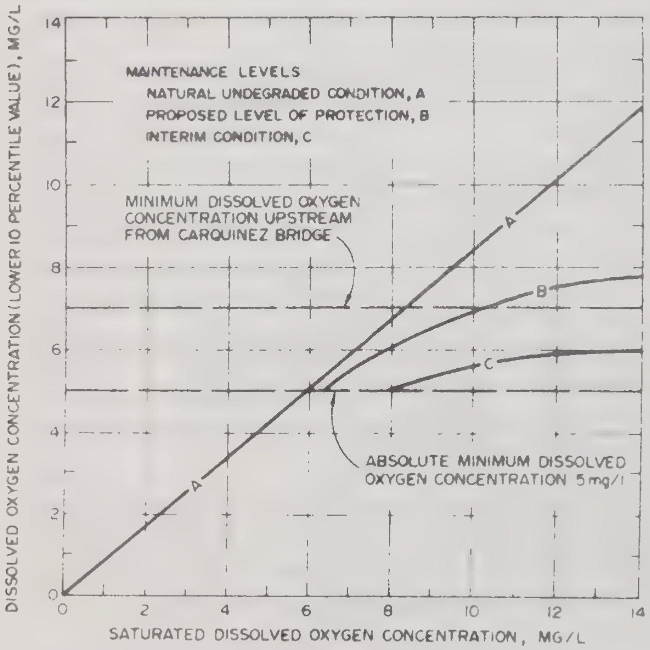


Figure 2 Lower 10 Percentile Dissolved Oxygen Concentration Value

For nontidal waters, the following objectives shall apply:

Waters designated as cold water habitat	7.0 mg/l minimum
Waters designated as warm water habitat	5.0 mg/l minimum

Areas of special biological significance shall be maintained at a level of protection consistent with natural undegraded conditions uninfluenced by any controllable water quality factor.

Where natural factors cause lower concentrations, controllable water quality factors shall not cause further reduction.

In addition to these limiting numerical objectives, dissolved oxygen concentration, lower 10 percentile value, shall be determined as a function of dissolved oxygen content at saturation, in accordance with Figure 2.

Biostimulatory Substances. Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.

Turbidity. All waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases from normal background light penetration or turbidity relatable to waste discharge shall not be greater than 10 percent in areas of 10 JTU or more; waters of characteristically low natural turbidity shall be maintained so that discharges do not cause visible, aesthetically undesirable contrast with the natural appearance of the water.

Sulfide. All waters shall be free from dissolved sulfide concentrations above natural background levels.

Coliform Bacteria. Water quality objectives for bacterial indicators are listed in Table 7.

Sediment. The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

Floating Material. Waters shall not contain floating material, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses.

Suspended Material. Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.

TABLE 8

Water Quality Objectives for Coliform Bacteria

Beneficial use	Receiving waters	Fecal coliform, MPN	Total coliform, MPN
REC-1	tidal	median < 50/100 ml; no sample to exceed 400/100 ml	median < 240/100 ml; no sample to exceed 10,000/100 ml
SHELL	tidal and nontidal		median < 70/100 ml; 90 percentile < 230/100 ml[b]
REC-1	nontidal	log mean < 200/100 ml; 90 percentile < 400/100 ml	-
REC-2[c]	nontidal	mean < 2000/100 ml 90 percentile < 4000/100 ml	-
MUN	nontidal	mean < 20/100 ml	mean < 100/100 ml

[a]Based on a minimum of five samples collected over a 30 day period.

[b]Based on a five-tube decimal dilution test or 300/100 ml when a three-tube decimal dilution test is used.

[c]Waters designate as REC-2 only; REC-1 not included.

Oil and Grease. Waters shall not contain oils, greases, waxes or other material in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses.

Color. Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses.

Tastes and Odors. Waters shall not contain taste or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, that cause nuisance or adversely affect beneficial uses.

Temperature. In addition to temperature objectives for "Enclosed Bays and Estuaries" as specified in the "Water Quality Control Plan for Control of Temperature in Coastal and Interstate Waters and Enclosed Bays of California, the following temperature objectives apply to surface waters.

The natural receiving water temperature of inland surface waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Board that such alteration in temperature does not adversely affect beneficial uses.

At no time or place shall the temperature of any COLD water be increased by more than 5°F above natural receiving water temperature.

At no time or place shall the temperature of WARM waters be increased more than 5°F above natural receiving water temperature.

Radioactivity. Radionuclides shall not be present in concentrations that are deleterious to human, plant, animal, or aquatic life nor that result in the accumulation of radionuclides in the food web to an extent that presents a hazard to human, plant, animal, or aquatic life.

Toxicity. All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration or other appropriate methods as specified by the Regional Board.

Pesticides. No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no increase in pesticide concentrations found in bottom sediments or aquatic life.

APPENDIX B

Characteristics of Stormwater Runoff

Probability of a Problem

- Public Health
- Total Suspended Solids
- Eutrophication

TABLE 9

CHARACTERISTICS OF STORMWATER RUNOFF

City	BOD (mg/ℓ)	Total solids (mg/ℓ)	Suspended Solids (mg/ℓ)	Coliform (number/ℓ)	Chlorides (mg/ℓ)	COD (mg/ℓ)
1. East Bay Sanitary District; Oakland, California						
Minimum	3	726	16	4	300	
Maximum	7,700		4,400	70,000	10,260	
Average	87	1,401	613	11,800	5,100	
2. Cincinnati, Ohio						
Maximum Seasonal Means	12	260				110
Average	17		227			111
3. Los Angeles County						
Average 1962-63	161	2,909			199	
4. Washington, D.C.						
Catch-basin samples during storm						
Minimum	6		26		11	
Maximum	625		36,250		160	
Average	126		2,100		42	
5. Seattle, Washington	10			16,100		
6. Oxney, England	100[a]	2,045				
7. Moscow, U.S.S.R.	186-285	1,000-3,500[a]				
8. Leningrad, U.S.S.R.	36	14,541				
9. Stockholm, Sweden	17-80	30-8,000		40-200,000		18-3,100
10. Pretoria, South Africa						
Residential	30			240,000		29
Business	34			230,000		28
11. Detroit, Michigan	96-234	310-914	102-213[b]	930,000[a]		

[a]Maximum

[b]Mean

Source: Water Pollution Aspects of Urban Runoff, APWA

TABLE 10

Characteristics of Urban Stormwater

Characteristic	Range of Values
BOD_5 (mg/l)	1->700
COD (mg/l)	5-3,100
TSS (mg/l)	2-11,300
TS (mg/l)	450-14,600
Volatile TS (mg/l)	12-1,600
Settleable solids (ml/l)	0.5-5,400
Organic N (mg/l)	0.1-16
NH_3N (mg/l)	0.1-2.5
Soluble PO_4 (mg/l)	0.1-10
Total PO_4 (mg/l)	0.1-125
Chlorides (mg/l)	2-25,000†
Oils (mg/l)	0-110
Phenols (mg/l)	0-0.2
Lead (mg/l)	0-1.9
Total coliforms (no./100 ml)	$200-146 \times 10^6$
Fecal coliforms (no./100 ml)	$55-112 \times 10^6$
Fecal streptocci (no./100 ml)	$200-1.2 \times 10^6$

† With highway deicing.

Source: Field, R., and E . Struzeski, 1972, Management and Control of Combined Sewer Overflows, JWPCF 44.

Public Health

In a preliminary impact analysis, total coliform bacteria are considered as an indicator of the potential for health problems which arise from direct contact with the water. Since direct human contact with water usually occurs during the summer months, an annual average impact analysis is improper in most areas and only summer average on storm event analyses are performed.

For the interpretation of the results of a preliminary coliform analysis Table 11 can be used for guidance. In addition, a recent study by Johns Hopkins University , which relates total coliform bacteria to water-borne disease causing organisms, may aid in the interpretation of results.

TABLE 11

TOTAL COLIFORM ANALYSIS

If the Calculated Concentration Is:	Probability of a Coliform Problem
less than 100/100 ml	Improbable
less than 1000/100 ml	Possible
more than 1000/100 ml	Probable
more than 10,000/100 ml	Highly Probable

The interpretation of total suspended solids concentrations, TSS, are tentatively based on the levels indicated in Table 12.

TABLE 12.

TOTAL SUSPENDED SOLIDS

If Calculated Concentration is:	Probability of a Problem
Less than 10 mg/l	Improbable
Less than 100 mg/l	Potential
More than 100 mg/l	Probable

Source: EPA, 1976, Areawide Assessment Procedures Manual Vol. I.

Eutrophication

The preliminary analysis of eutrophication is based on the following reasoning. If excessive quantities of both nitrogen and phosphorus exist, it is likely that, given the proper environment, algae will grow. Since the precise determination of these conditions is beyond the scope of a preliminary analysis, it is assumed that, in the absence of any contradictory data, conditions will be favorable for growth. Therefore, if the concentrations of both nutrients are in excess of growth requirements, a potential eutrophication problem exists. The interpretation of the calculated concentration of total nitrogen (TN), and total phosphorus (TP) nutrients in the receiving water is shown in Table 13.

TABLE 13.
EUTROPHICATION ANALYSIS

If the Calculated Concentration is:	Probability of a Problem
TN less than 0.01 mg/l *or* TP less than 0.001 mg/l	Improbable
TN more than 0.1 mg/l *and* TP more than 0.01 mg/l	Potential
TN more than 1.0 *and* TP more than 0.10 mg/l	Probable

It is recognized that these concentrations are quite low and there are situations for which these concentrations are exceeded and no substantial biomass develops. Environmental factors, such as climate, geomorphology of the receiving water, turbidity, etc., are as important in determining whether a problem will develop as are the concentrations of available

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Source: EPA, 1976, Areawide Assessment Procedures Manual, Vol I.

APPENDIX C

Surface Runoff Data From Specific Studies

The following tables summarize data from selected stormwater sampling programs. The data illustrates the large variations in surface runoff quality both during a storm and between storm events. All of these studies were taken from the 1975 American Water Resources Association symposium Urbanization and Water Quality Control.

Table #	City	Watershed Description
14	Chester, Penn.	Industrial
15	Woodlands, Tex.	Residential
16	Greenfield, Mass.	Mixed Urban
17	Durham, N.C.	Mixed Urban
18	Lodi, N.J.	Mixed Urban
19	Lodi, N.J.	Mixed Urban
20	Denver, Col.	Residential

TABLE 14

Summary of Data. (All units are mg per liter except as noted.)

Composite Samples	Storm 1	Storm 2	Storm 3	Overall
Fecal coliform (colonies/100 ml)	91,800	710,000	2,000	268,000
Total solids	368	535	197	366
Total volatile solids	89	77	35	67
Suspended solids	179	62	93	111
Volatile suspended solids	53	43	17	39
Settleable solids, ml/l	2.7	1.0	0.8	1.5
Total alkalinity as $CaCO_3$	64	230	44	113
Ammonia - N	6	17	4	9
Nitrate - N	.2	.1	.1	.1
Nitrite - N	2.2	1.3	1.7	1.7
Total Kjeldahl - N	7	19	4	10
Total phosphate as PO_4	11	20	5	12
Chloride	25	59	10	31
Synoptic samples:				
Total organic carbon	51	71	37	53
pH	6.9	7.5	6.8	7.0
BOD_5	105	100	59	88

TABLE 15

Summary of Suspended Solids, Total COD, Total Phosphorus, and Kjeldahl Nitrogen Characteristics of Stormwater Runoff for The Woodlands.

Date of Storm Event	Peak Discharge, cfs	Pollutant Concentration, mg/l		Pollutant Loading	
		Peak	Average	Lbs	Lbs/sq mi-in.
		SUSPENDED SOLIDS			
1-18-74	1,260	2,090	250	1,500,000	36,000
4-22-74	9.6	1,600	980	15,000	140,000
10-28-74	111	984	740	87,000	110,000
10-28-74	195	1,260	840	330,000	120,000
12- 5-74	305	719	86	290,000	13,000
4- 7-75	1,100	672	170	1,200,000	25,000
		TOTAL COD			
4-22-74	9.6	124	93	1,400	13,000
12- 5-74	305	73	57	190,000	8,300
4- 7-75	1,100	75	48	340,000	7,000
		TOTAL PHOSPHORUS (P)			
4-22-74	9.6	1.14	.5	7.1	68
10-28-74	111	.36	.3	34	42
10-28-74	195	.27	.2	70	26
12- 5-74	305	.53	.1	340	15
4- 7-75	1,100	.48	.1	620	13
		KJELDAHL NITROGEN (N)			
4-22-74	9.6	2.1	1.4	22	210
12- 5-74	305	2.2	.9	3,100	130
4- 7-75	1,100	4.1	1.4	9,900	210

TABLE 16

Urban Runoff Loadings in Greenfield, Massachusetts, January 1975 June 1975.

	BOD_5 Lbs/Sq Mile/Day	BOD_5 Lbs/Cap/Day	P Lbs/Sq Mile/Day	CL Lbs/Sq Mile/Day
Mean Dry Weather	58	0.07	0.8	262
Range	26-224	0.03-0.26	1.2-3.0	70.4-730
Other Studies (Whipple, *et al.*, 1974)	39[1]	.0172[1]	12.8[1]	- -
Mean Wet Weather	269	0.31	15	717
Range	102-755	0.12-0.86	4.0-70.4	204-1702
Other Studies (Whipple, *et al.*, 1974)	154[1]	0.068[1]	112, 548[2]	
(Colston, 1974)			35[3]	
(Bryan, 1972)	147		19	76.8

[1] For Morristown, New Jersey.

[2] Phosphorus loading from New Brunswick, New Jersey, a highly industrialized area which includes municipal discharges of sewage.

[3] Daily loading rate calculated from annual average of 243 lbs/sq mile/year as given by Colston (1974) and assuming 19% occurrence of wet weather with neglible loading on dry weather days.

TABLE 17

Average, Range, and Standard Deviation of Pollutant Concentrations for All Storm Samples

Pollutant	Mean, mg/l	Standard deviation	Range (mg/l) Low	Range (mg/l) High
COD	170	135	20	1042
TOC	42	35	5.5	384
Total Solids	1440	1270	194	8620
Volatile Solids	205	124	33	1170
Total Suspended Solids	1223	1213	27	7340
Volatile Suspended Solids	122	100	5	970
Kjeldahl Nitrogen as "N"	.96	1.8	.1	11.6
Total Phosphorus as "P"	.82	1.0	.2	16
Fecal Coliform (#/ml)	230	240	1	2000
Aluminum	16	8.15	6	35.7
Calcium	4.8	5.6	1.1	31
Cobalt	.16	.11	.04	.47
Chromium	.23	.10	.06	.47
Copper	.15	.09	.04	.50
Iron	12	9.1	1.3	58.7
Lead	.46	.38	0.1	2.86
Magnesium	10	4.0	3.6	24
Manganese	.67	.42	.12	3.2
Nickel	.15	.05	.09	.29
Zinc	.36	.37	.09	4.6
Alkalinity	56	30	24	124

TABLE 18

Comparison of Heavy Metals in Stormwater Reported by Others with an Urban Drainage Area in Lodi, New Jersey (mg/l).

Metal	Location				
	Durham, North Carolina[1]	New York, New York[2]	Palo Alto, California[3]	Oklahoma City, Oklahoma[4]	Lodi, New Jersey
Lead	0.46	–	0.093	0.23	0.90
Zinc	0.36	1.6	–	–	0.62
Copper	0.15	0.46	–	–	0.15
Chromium	0.23	0.16	–	–	0.03
Nickel	0.15	0.15	–	–	0.08

[1] Colston, 1974
[2] Klein, *et al.*, 1974
[3] Hem and Durum, 1973
[4] Newton, *et al.*, 1974

TABLE 19

Average and Standard Deviation of Heavy Metals Concentrations in Urban Runoff for Seven Different Storm Events for Two Different Basins.

Storm No.	Sub-basin	Lead mg/l		Zinc mg/l		Copper mg/l		Nickel mg/l		Chromium mg/l	
		Avg.	σ	Avg.	σ	Avg.	σ	Avg.	σ	Avg.	σ
1	1	.975	.88	.304	.31	.296	.29	.025	.092	.031	.043
2	1	1.28	.51	1.09	.783	4.62	7.86	.108	.065	.029	.008
3	1	1.29	.85	.312	.112	.073	.035	.039	.027	.023	.013
4	2	.935	.28	.782	.26	.099	.033	.15	.077	.044	.017
5	2	.417	.31	.321	.234	.061	.014	.017	.027	.017	.022
6	2	.721	.28	.402	.167	.13	.056	.053	.009	.04	.023
7	2	.549	.22	.177	.057	.062	.024	.027	.008	.015	.012

TABLE 20

Characterization of Runoff from a Residential Area , Denver Street Drainage Basin - September 3, 1974[2].

Parameter	Mean Concentration, Mg/l	Total Loading, Lbs[3]	Areal Loading, Lbs/Sq Mi	Estimated Annual Areal Yield, Lbs/Sq Mi/Yr[4]	Equivalent Secondary Effluent[5]	
					Mg/l	Lbs
TOC	28	52	166	11,904	20	47
Susp. Solids	750	1,407	4,422	320,000	20	47
Nitrite - N	0.04	0.07	0.24	17	0	0
Nitrate - N	.30	.56	1.78	128	2.5	5.9
Ammonia - N	.50	.94	2.96	214	15	35
TKN	3.50	6.57	20.8	1,498	16.3	38
Total - N	3.84	7.20	20.8	1,638	18.8	43
Ortho - P	0.45	.84	6.53	192	6	14
Total - P	1.10	2.06	2.69	470	5	12

F. Wolin

RAINWATER QUALITY AND ITS IMPLICATIONS ON SURFACE RUNOFF

TECHNICAL MEMORANDUM NO. 6
FEBRUARY 23, 1977

A. Introduction

It is increasingly evident that rainwater contains various pollutants prior to reaching the ground. The environmental impact of precipitation-borne pollutants has become an important area of research in Europe, Canada, and the northeastern United States.

The purpose of this technical memorandum is to research the available information on precipitation chemistry in the San Francisco Bay Area and to compare it with data available elsewhere. Pollutant loading of rainwater and the need for rainwater quality monitoring will also be discussed. The specific topics to be addressed by this memorandum are:

- what are the components of rainwater,
- what environmental problems are associated with precipitation quality,
- what are the factors affecting rainwater quality,
- monitoring precipitation-borne pollutant loads,
- what is the data base for precipitation quality in the Bay Area, and
- what can be learned from precipitation monitoring in the Bay Area.

B. Discussion of problems associated with precipitation

The components of rainwater are diverse in size and form. Some are gases, others are dust particles, industrial pollutants, heavy metals, pesticides, fertilizers, pollen, microorganisms, PCB's and smoke particles.

Increasing population, industry and new technologies, such as geothermal power generation, are producing greater atmospheric pollutant loads. As a result, acid precipitation has become of increasing concern.[1] Acid precipitation is a phenomenon caused by the lowering

[1] Oden, Svante, The Acidity Problem--An Outline of Concepts, Dept. of Soil Science, Division of Ecochemistry, Agricultural College, Uppsala, Sweden.

of rainwater pH by chemical reactions in the atmosphere. It is defined as rainwater at a pH value less than 5.6.[2] The consequences of acid precipitation have yet to be fully evaluated, however, acid precipitation has been linked to large reductions in the number of fish in lakes and streams. Acidification of soils has caused economic losses to agriculture.[3] Acid rain has been blamed for the increased weathering of rock and man-made structures, and evidence of damage to plant and animal ecosystems has been reported. The cause of this phenomena has been identified as the burning of fossil fuels and the subsequent release of sulfur dioxide into the atmosphere.

Research has been done on nutrient loading of large water bodies by precipitation. It was determined by studies at Clear Lake, California and at Lake Tahoe that as much as fifty percent of the total yearly nutrient load of the lakes comes from precipitation and surface water runoff.[4]

Another effect on the environment is related to the loading function of the non-point sources of pollution. Precipitation contains significant amounts of nutrients and pollutants. Some of the constituents commonly found in rainwater are: nutrients (nitrogen, phosphorus, sodium, chloride, and calcium) and pollutants (industrial chemicals, heavy metals, pesticides, and polychlorinated biphenyls).

Unfortunately, the small amount of regional rainwater quality data in the Bay Area prevents assessment of the extent of the regional problem.[5] Figure 1 (Map of Bay Basin) shows the extent of precipitation chemistry research done in the Bay Area. It is apparent that the number and the area coverage of the studies carried out in the past is insufficient and that much more monitoring is needed to provide an adequate data base for the Bay Area.

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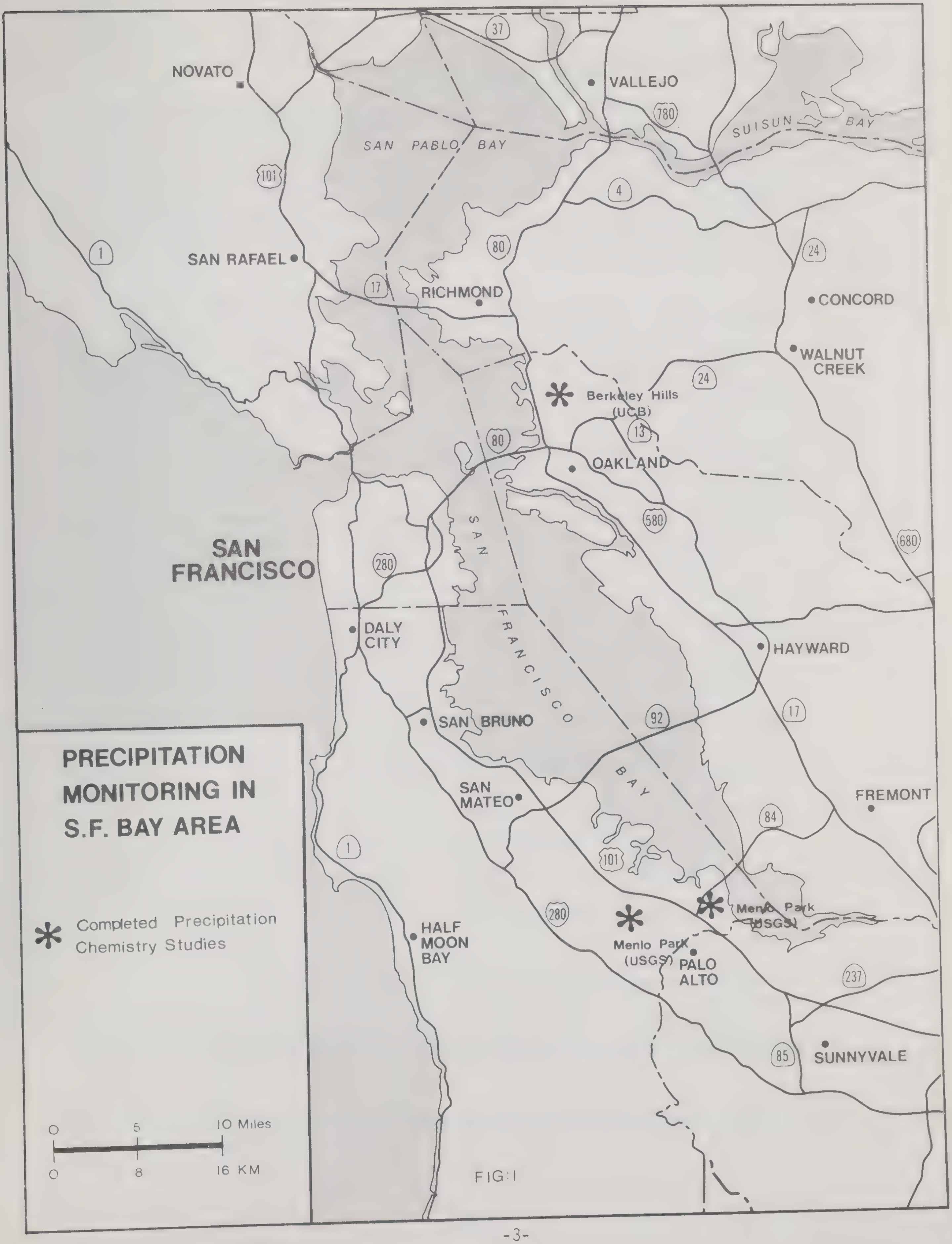
[2]Likens, Gene E. Acid Precipitation, Section of Ecology and Systematics, Cornell University C and EN Special Report November 22, 1976.

[3]Norton, Stephan A. Changes in Chemical Processes In Soil Caused by Acid Precipitation Contribution to Proceedings of the First International Symposium on Acid Precipitation and The Forest Ecosystem. U.S.D.A./F.S., Upper Darby P.A. 19082.

[4]Clear Lake Algal Research Unit, Clear Lake Ecology - The Ecology of Clear Lake Phytoplankton, 1975.

[5]Richardson, Curtis J. The Chemical Composition of Atmospheric Precipitation From Selected Stations in Michigan. Department of Agricultural Engineering, University of Michigan.


PRECIPITATION MONITORING IN S.F. BAY AREA
Completed Precipitation Chemistry Studies
0 5 10 Miles
0 8 16 KM
NOVATO
VALLEJO
SUISUN BAY
SAN PABLO BAY
SAN RAFAEL
RICHMOND
CONCORD
WALNUT CREEK
Berkeley Hills (UCB)
OAKLAND
SAN FRANCISCO
SAN FRANCISCO BAY
DALY CITY
HAYWARD
SAN BRUNO
SAN MATEO
FREMONT
HALF MOON BAY
Menlo Park (USGS)
Menlo Park (USGS)
PALO ALTO
SUNNYVALE
37
780
101
4
1
80
17
24
13
580
680
280
92
84
237
85
FIG:1

C. Determination of rainwater quality

Rainwater quality, like surface water quality, is difficult to establish due to its marked variability. Phenomena such as volcanic eruptions, dust storms, particulate inputs from space, electrical disturbances, and chemical releases to the atmosphere from the earth all contribute to the dynamic atmospheric system and make the establishment of standards for rainwater quality difficult. Several attempts have been made to define the quality of unpolluted rainwater. Examples of these include:

1. Core samples of the Greenland Ice Cap were analyzed for content, and compared with present values.

2. Data from early precipitation monitoring efforts were compared with present day results, and baseline values were established.

3. A pH value of 6.0; this, according to some researchers, is the expected equilibrium pH of CO_2 dissolved in water.

4. A pH value of 5.6; this is the expected pH of rainwater in equilibrium with high ambient concentrations of atmospheric carbon dioxide.

The apparent confusion in establishing the baseline quality of rainwater compounds the problem of identifying factors which influence precipitation quality. Factors known to affect rainwater quality are:

1. Prevailing wind direction.

2. Wind velocity.

3. Frequency of past storms and their intensities.

4. Meteorological conditions before storm - inversion, temperature, humidity, etc.

5. Origin of storm.

6. Geographical influences - hills, oceans, mountain ranges, basins, etc.

7. Vegetation - open area, canopied, protected, type of vegetation.

8. Man-made sources of pollution.

It is generally difficult to address all of these factors in a single study. No indication was available to what extent that these factors were considered in the references of this paper.

D. Monitoring atmospheric pollutant loads

A major study completed by the United States Geological Survey, Menlo Park, California for the years 1957-1959 is an example of how precipitation monitoring can be done.[6] The investigators divided precipitation into two major catagories:

1. Rainwater

2. Dry fallout (aerial deposition)

Rainwater is defined, in this study, as "precipitation that falls as liquid water and is sampled using a freshly cleaned, nonreactive collector." "Dry fallout consists of the water-soluble part of dust, occluded gases, and other constituents of unexplored nature that fall on the collector between rains and are washed into the bottle with distilled water." The sum of these components equals the atmospheric pollutant contribution and is called the bulk precipitation. Due to its greater concentrations of chemicals and pollutants it is considered the most important fluid to study in precipitation research. A copy of this report can be found in the appendix of this memorandum. This study is indicative of a good precipitation monitoring effort.

The amount of aerial fallout is directly related to the amount of air pollution present in the study area. Figure 2 shows air pollution trends projected to the year 2000. Emissions are expected to increase. The effect on rainwater chemistry will be increased pollutant loads and a higher probability for acid precipitation. The data from air pollution monitoring combined with data from rainwater quality monitoring would produce valuable results. They will be used in determining pollutant loads and sources in surface water runoff monitoring programs.

It is difficult to use data from previous Bay Area precipitation studies with confidence. The studies have been taken over a 20-year period and the methods of investigation have been significantly different, making comparison of results difficult if not impossible.

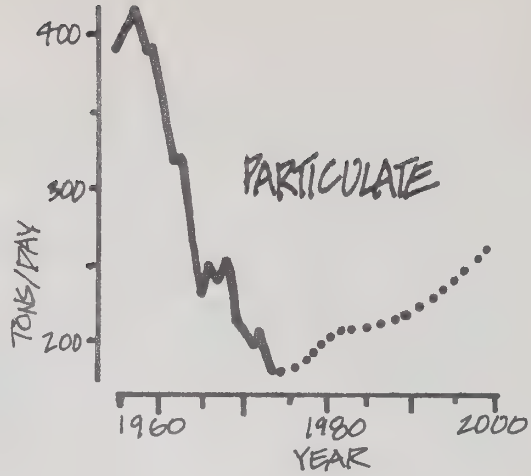
Standards for precipitation research techniques have been lacking in past studies.[7] Only recently has this problem been addressed by

[6]H.C. Whitehead and J.H. Feth, Chemical Composition of Rain, Dry Fallout and Bulk Precipitation at Menlo Park, California 1957-1959, Journal of Geophysical Research Vol 69, No. 16, August 15, 1964.

[7]Vance Kennedy, et al., Composition of Selected Rain Samples Collected at Menlo Park, California in 1971, USGS Open File Report 76-852, Menlo Park, California.

BAY AREA TRENDS IN AIR POLLUTION EMISSIONS

THE GRAPHS BELOW SHOW FOR EACH OF THE FIVE MAIN AIR CONTAMINANTS THE VARIATION IN TONS/DAY EMISSIONS THROUGH THE YEARS. SOLID PORTIONS OF THE CURVES REPRESENT HISTORICAL EMISSIONS WHICH HAVE BEEN ADJUSTED SO AS TO BE CONSISTENT WITH THE 1974 SOURCE INVENTORY AND THE LATEST COMPUTATION TECHNIQUES. DOTTED PORTIONS OF THE CURVES INDICATE ESTIMATED EMISSIONS FOR THE FUTURE.



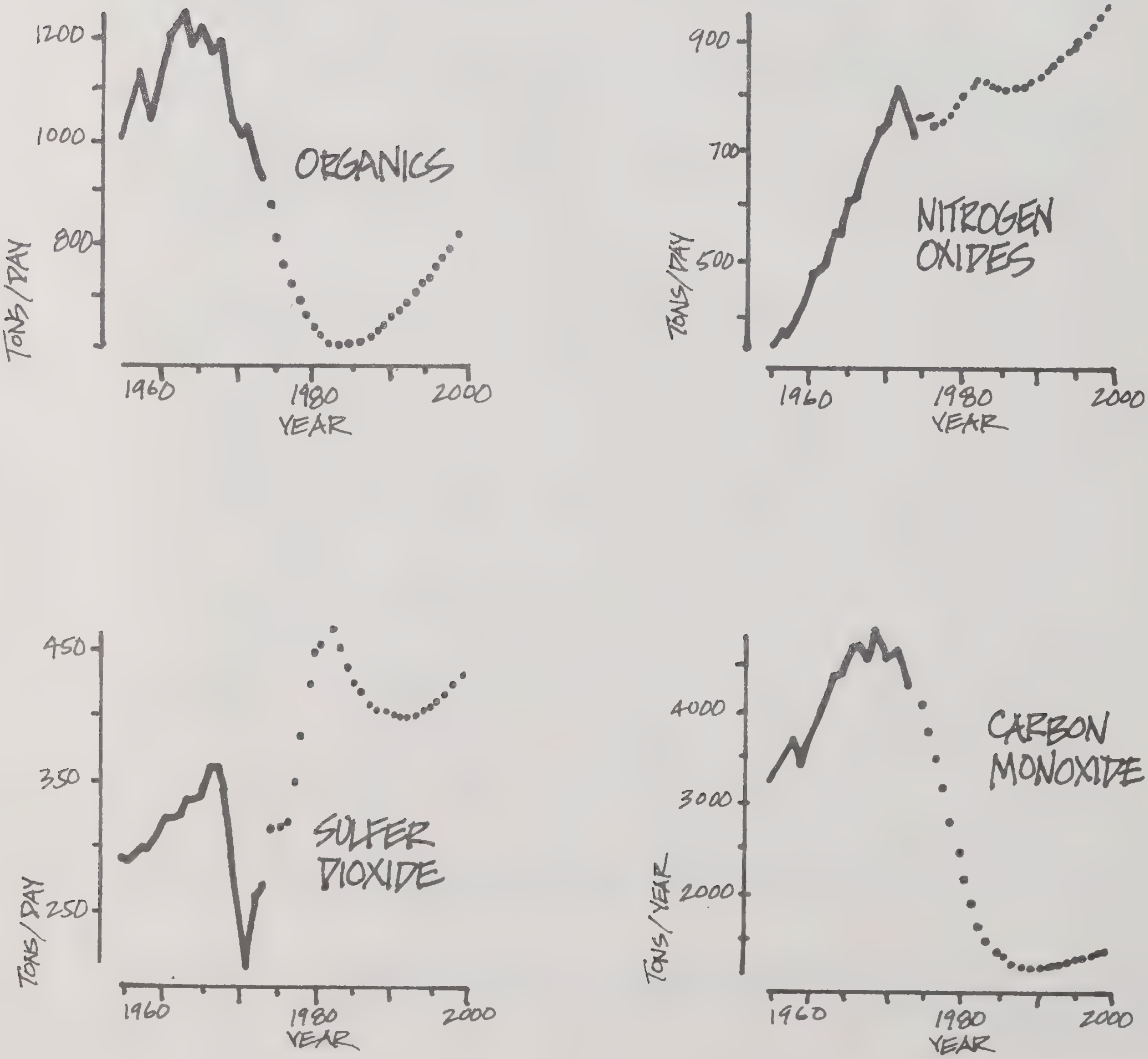


FIGURE 2
ADAPTED FROM BAAPCD

researchers in the field. An example of how techniques could be standardized is shown below:

1. Precipitation samples must be divided into dry deposition and rainwater deposition if accurate information on chemical content of rainwater is required.

2. The type of collector to be used to sample different parameters must be determined.

3. Storage of samples and fixing methods must be uniform.

4. Improved laboratory techniques are necessary to analyze samples.

5. Standardization of measurements for sampling need to be established.

6. Accurate data recording at the collection site and in the laboratory is necessary.

7. Uniform parameters must be established for precipitation monitoring.

The Bay Area contains many reservoirs and water supply systems that are directly dependent upon local precipitation quality. Some of the reservoirs are also dependent upon precipitation as a source of clean water for urban uses. Other reservoirs that are used to store imported water from the Sierra Nevada Mountains are dependent upon the quality of local surface water runoff and the content of bulk precipitation for water quality in the local reservoirs.

The weather patterns in the Bay Area are influenced greatly by the proximity of the Pacific Ocean. Most of the storms reaching the Bay Area are of oceanic origin. Due to the lack of contact with land derived contaminants, they are considered clean storms until they reach the coast. A storm that is considered as clean before reaching the coast will contain significant pollutant loading just a few miles inland. Storms approaching the Bay Area overland have higher pollutant loads than those approaching from the ocean. The greater pollutant loads for an overland storm are determined by the distance the storm travels overland and the nature of the pollutants it encounters along the storm path. Monitoring of precipitation would help determine what water quality problems are associated with the different storm type sequences.[8]

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[8] McColl, John, Chemistry of Precipitation in the Berkeley Hills, 1974-1975 University of California, Berkeley (unpublished at this time).

E. Data available

In Europe a continuous rain monitoring network has been established and precipitation research is considered an important part of environmental problem solving.[9] The emphasis of the European studies is on the control of acid precipitation as this has been identified as a major problem. Their methods for collection of samples and their laboratory techniques are ahead of those used in the United States. Unfortunately, the results and findings of the Europeans cannot be directly applied to problems in the United States due to the geographic and other differences between these areas.

In the United States most of the precipitation research has been limited to the northeastern portion of the country. Here again, the major problem has been identified as acid precipitation. Other problems associated with precipitation are stated by Tabatabai and Laflen:[10]

> "The atmospheric component of the cycles of nitrogen and sulfur often can be a significant part of the various pools of their respective cycles, but the atmospheric component of phosphorus cycle seems to be of minor significance to the cycling of this element in the environment. Among the various chemical elements present in precipitation (e.g., nitrogen, sulfur, potassium, chloride and calcium), nitrogen and sulfur deserve special attention, because nitrogen added by precipitation may contribute to nitrate pollution of surface and ground water. Sulfur may cause acid rain that can lead to increased leaching from soils of calcium and other nutrient elements, deterioration of aquatic ecosystems, damage to vegetation and buildings, and other agricultural and urban problems."

Figure 3 shows the content of precipitation from selected studies in areas outside of the Bay Basin. Information of this type is needed for the San Francisco Bay Area to establish a workable data base. Unfortunately, due to the lack of such a data base in the Bay Area, there is no way of determining the extent of precipitation-related problems in the Bay Basin.

F. Data base in the San Francisco Bay Area

Major studies on precipitation quality for the San Francisco Bay Area are: (See Figure 4)

1. Chemical Composition of Rainwater, Dry Fallout, and Bulk Precipitation at Menlo Park, California 1957-1959. U.S.G.S., Menlo Park, California.

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[9] Overrein, Lars N. A presentation of the Norwegian Project. Acid Precipitation - Effects on Forest and Fish. SNSF Project 1432 AAS - NLH, Norway

[10] M.A. Tabatabai and J.M. Laflen, Nutrient Content of Precipitation Over Iowa, Iowa State University and Agricultural Research Service, Ames, Iowa.

FIGURE 3

RESULTS OF SELECTED PRECIPITATION STUDIES

STUDY AREA	PARAMETERS MONITORED mg/l																					
	PH	SO_2	Cl	K	Na	Ca	NO_3	NH_3	OrgN	P	Mg	Cu	Fe	Mn	Zn	Cd	Hg	Ni	Pb	*DDT	PCB	MISC
SOUTHERN CALIFORNIA BIGHT												.01	.001	.012	.005		.0002			1.0-3.0		
CLEAR LAKE CALIFORNIA							.29	.16	.37											1.0-3.0		
HUBBARD BROOK		2.9	.47	.07	.12	.16	1.47			.008	.04									1.0-3.0		
U.S. COAST STATION		2.45	4.3		3.68	.58														1.0-3.0		
U.S. INLAND STATION		2.14	.22		.42	1.41														1.0-3.0		
N. EUROPE INLAND STATION		5.37	2.57		1.22	1.54														1.0-3.0		
SANTA BARBARA																			.0002	1.0-3.0		

- NOTE: ALL VALUES ON CHART ARE APPROXIMATE

*AVERAGE FOR U.S. RAINFALL

FIGURE 4

RESULTS OF BAY AREA PRECIPITATION STUDIES

STUDY AREA	PARAMETERS MONITORED mg/l																				
	pH	SO_2	Cl	K	Na	Ca	NO_3	NH_3	OrgN	P	Mg	Cu	Fe	Mn	Zn	Cd	Hg	Ni	Pb	DDT	Pcb
BERKELEY HILLS STUDY U.C.B. 1975	5.03	3.0	1.59	.35	1.22	.43	2.7			.12	.07	.005	.013	.003	.016						
USGS WHITEHEAD AND FETH MENLO PARK 1957-1959	6.4	12.2	7.28	.71	3.94	6.70	2.56				2.96										
USGS VANCE KENNEDY MENLO PARK 1972-75	BU's 3 SITE 5.8		.99	.1	.55	.18	.15				.13										
	BAY SHORE SITE 5.43	.70	1.38	.23	.80	.24	.156				.125	.001	.002	<.001	.104	<.001		1.25			
BAY BASIN STUDY ABAG 1975							1.0			.1		.021			.107		.0004	.0043	.034	.0001	.0001
USGS SPECIAL STUDY ON Cd+Zn BY DR. HEM															11.5	.0095					

NOTE: ALL VALUES ON CHART ARE APPROXIMATE.

2. Chemistry of Precipitation in the Berkeley Hills, University of California, Berkeley, 1974-1976.

3. Composition of Selected Rain Samples Collected at Menlo Park, California in 1971. U.S.G.S., Menlo Park, California.

The results of these studies indicate:

1. Pollution sources outside of the Bay Area affect the quality of Bay Area precipitation.

2. There are variations in the concentration of pollutants in precipitation depending on the type of land use that is in the monitoring area.

3. Precipitation contains significant amounts of particulates, nutrients and other pollutants.

4. There seems to be a trend toward acidic conditions for precipitation in the Bay Area.

5. Precipitation is indicated as a source of nutrient loading for surface water and surface water runoff.[11]

6. Precipitation has been found to contain heavy metal pollution.

7. A combination of air quality data and precipitation data would be necessary to determine the total atmospheric contribution to surface water and surface water runoff.

The Bay Basin Plan produced by the State Water Resources Control Board[12] indicates that precipitation contributes to the pollutant and nutrient loading of Bay waters. The study attempts to show that an atmospheric pollution problem exists, but little data is available to substantiate their conclusions.

It is evident that the data base in the Bay Area is not well developed and is lacking in continuity. More work needs to be done before a clear picture of precipitation-related problems emerges for the Bay Area.

G. Summary

It is known that precipitation-borne pollutant loads and nutrient loads have caused problems in other areas. The amount and effect of precipitation pollution on surface water and surface water runoff have yet to be determined for the Bay Area. Better information on Bay Area bulk precipitation would provide decision-makers with the relative importance of atmospheric pollution to surface water runoff and the Bay Area Environment. Therefore, sampling of rainwater quality should be under consideration in the design of future water quality monitoring programs for the San Francisco Bay Area.

[11] Large Lakes Research Unit, Atmospheric Loading Inputs to the Great Lakes System. Grosse Ile, Michigan.

[12] SWQCB. Water Quality Control Plan Report, San Francisco Bay Basin (2) 1957.

APPENDIX

"Chemical Composition of Rain, Dry Fallout and Bulk Precipitation at Menlo Park California 1957-1959", H.C. Whitehead and J.H. Feth, Journal of Geophysical Research Vol. 69, No. 16 August 15, 1964.

Chemical Composition of Rain, Dry Fallout, and Bulk Precipitation at Menlo Park, California, 1957–1959

H. C. Whitehead and J. H. Feth

Water Resources Division, U. S. Geological Survey
Menlo Park, California

Abstract. Winter precipitation is defined as rain, dry fallout, and bulk precipitation—the last being a mixture of the other two. The division of winter precipitation into phases is based on collection procedures. Each phase shows distinctive characteristics of chemical composition. Rain displays the strong influence of the nearby Pacific Ocean and San Francisco Bay. Dry fallout, collected between rains, shows strong effects from locally derived materials in the atmosphere. Bulk precipitation shows, in chemical composition, the expected blending of the two environmental influences and is about 4 to nearly 10 times higher in mineral concentration than rainwater is. Bulk precipitation is considered the geochemically significant phase that should be used in studies relating contributions of atmospheric salts to surface- and groundwater supplies, to weathering, and to the nourishment of growing plants. Comparison with published data indicates that, wherever sampled, bulk precipitation contains more dissolved mineral content than rainwater does. Detailed comparisons, however, are not feasible because of widely differing procedures in sampling and analysis used in various studies. Increasing attention should be given to minor constituents in precipitation, as well as recognition of the several phases of precipitation.

Introduction

During the winters of 1957–1958 and 1958–1959, samples of precipitation were collected at Menlo Park, California, as part of a study by the U. S. Geological Survey of the sources of mineralization in surface- and groundwater in the western United States. The analyses are grouped into categories designated 'rain,' 'dry fallout,' and 'bulk precipitation.' The distinctions are based on collection procedures and are defined below. The large differences in chemical composition found among the three groups imply that the distinctions made are significant. Bulk precipitation is probably the most significant category in many geochemical considerations.

Procedures in Sampling and Analysis

The precipitation collector was a semirigid sheet of polyethylene about 4 feet square, supported on a wooden frame that provided a gentle slope for drainage. The water collected drained through a polyethylene funnel into a 4-liter Pyrex bottle. The collector, situated on the roof of the U. S. Geological Survey building in Menlo Park, was serviced at various intervals. Its efficiency in collecting representative samples, especially of dry fallout between rains, cannot be evaluated from data in hand. Thus, comparisons with other studies are difficult. Dry fallout samples 796 to 799, inclusive (Table 1), which were taken from the roof or awning surfaces in the vicinity, suggest that rough-textured surfaces may retain more products of fallout than the smooth collector surface. But, as stated below, concentrations of constituents in dry fallout cannot be evaluated. The following definitions clarify the terms used.

Rain. Rain is precipitation that falls as liquid water and is sampled using a freshly cleaned, nonreactive collector.

Dry fallout. Dry fallout consists of the water-soluble part of dust, occluded gases, and other constituents of unexplored nature that fall on the collector between rains and are washed into the collecting bottle with distilled water. Analysis of the resulting solution has no meaning in terms of concentration because the volumes of air that yielded samples of dry fallout are unknown. Furthermore, the concentration depends on the amount of water used to wash the collector. The ratios of most constituents probably have significance, however.

Bulk precipitation. Bulk precipitation is a mixture of rain and dry fallout. As sampled, bulk precipitation is the solution formed when

dry fallout is washed into the collecting vessel by rainwater. In nature, melting snow, or rain falling on the land surface—whether in its native state or modified by man—collects and incorporates the products of dry fallout. The resulting solution is bulk precipitation.

Bulk precipitation displays the combined effects of all water-soluble airborne components of precipitation. It is the most significant fluid to study in evaluating contributions of atmospheric mineralization to the chemical quality of natural water. Bulk precipitation is the geochemically active agent in rock weathering and formation of soil and is the solution that provides moisture to growing vegetation. This distinction between 'rain' and 'bulk precipitation' is not always made in reporting chemical analyses of 'precipitation.' The geochemical evaluation of analyses where the methods of sampling are not explained is difficult or impossible to make.

The analytical methods used were those currently employed by the U. S. Geological Survey [*Rainwater and Thatcher*, 1960] with the exception that chloride was determined by the colorimetric method reported by *Iwasaki et al.* [1952] and *Bergman and Sanik* [1957]. The iodide determinations on samples collected during the winter of 1958–1959 were made by a catalytic method [*Zak*, 1958]. Because the samples were dilute, large aliquots were used in some of the determinations, the largest being 1 liter for sulfate and bromide.

The concentrations of most individual constituents in rainwater are less than 5 ppm and commonly less than 1 ppm. Variation in the concentrations of several constituents is evident in Table 1, but the variations in the majority of cases are slight. To see if this variation is real or inherent merely in the analytical procedures, a comparison of variance was made by means of the F ratio [*Dixon and Massey*, 1957]. For this comparison, the variance of the analytical procedure for a constituent was doubled to simulate the effect of sampling errors and changes during storage. Means and variances were calculated for the concentrations of Ca^{+2}, Mg^{+2}, Na^{+1}, K^{+1}, HCO_3^{-1}, SO_4^{-2}, and Cl^{-1} in rainwater, bulk precipitation, and dry fallout. The ratio (F) of the sample variance (s^2) to the doubled analytical variance (σ^2) was assumed to follow a normal χ^2 distribution, and the hypothesis ($s^2 = \sigma^2$) was tested on this basis at the 95% confidence level. In all cases, with the exception of potassium in rainwater during 1958–1959, the calculated F was beyond the critical limits, indicating that the variations seen for these constituents in Table 1 are statistically significant.

Location and Climate

Menlo Park is about 30 miles southeast of San Francisco, California, near the southern end of San Francisco Bay and in the northern part of the Santa Clara Valley (Figure 1). The valley has a Mediterranean climate [*Dale*, 1959] (winter rains and dry summers). Temperatures are mild; frost is rare and summer temperatures higher than 80°F occur on relatively few days of the year. Annual average rainfall at Redwood City and Palo Alto, both adjacent to Menlo Park, is 19.42 inches and 15.49 inches, respectively. The rainy season lasts from October through March in most years.

The Santa Clara Valley is partly shielded from direct maritime winds by the range of mountains to the west. Also, during most of the summer and fall, a temperature inversion exists, having its base at an average altitude of 1200 to 1500 feet [*Robinson*, 1959]. On occasion, there are also stable inversions between storms in the winter. These inversions act as a lid on the valley and prevent vertical transport of most of the locally produced air contaminants. Under stable meteorological conditions, oceanic salts appear to have but little influence on the chemical composition of the precipitation. In contrast, when the air is turbulent, the influence of sea salts is commonly apparent.

Chemical Composition of the Samples

Major constituents. The chemical compositions of samples of precipitation at Menlo Park are given in Table 1 and summarized in Table 2*a*. The general chemical composition of the three categories of precipitation is illustrated by the diagrams (Figures 2, 3, 4, and 5). The diagrams reflect the percentage compositions of the samples in terms of reacting values of the major cations and anions. In this procedure (see example, Figure 2), the sum of cation epm (equivalents per million) of a sample is taken as 100% and the percentage of the individual cation is calculated from this base and plotted

TABLE 1. Chemical Composition of Rainwater, Dry Fallout, and Bulk Precipitation at Menlo Park, Calif., 1957–1959
(Analytical results in parts per million except as indicated.)

Lab. No.	Collection Period	SiO_2	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	HCO_3^{-1}	SO_4^{-2}	Cl^{-1}	F^{-1}	Br^{-1}*	I^{-1}*	NO_2^{-1}	NO_3^{-1}	B	Dissolved Solids Calculated	Hardness as $CaCO_3$	Noncarbonate Hardness as $CaCO_3$	Specific Conductance (micromhos at 25°C)	pH
	Rainwater																			
545	1100–1200, 12/17/57	0.2	1.6	0.0	5.0	1.2	3	2.1	7.0				0.04	0.5		19.0	4.0	2	49	5.9
546	1600, 12/17/57, to 0800, 12/18/57	0.1	0 8	0 0	2.3	0.5	1	0.4	4.0				0.01	0.0			8.8	1 0	15	5.8
549	1600, 12/23/57, to 0905, 12/24/57	1.0	1.6	0 2	1 7	0.7	5	2.8	3.3	0.0	0.05	0.0	0.02	0.4	0.04	14.0	5.0	1	26	6.3
532	1900, 1/9/58, to 0800, 1/10/58	1.2	1.2	0.7	0.0	0.0	7	0.7	0.8	0.0			0.00	0.2		8.2	6.0	1	18	6.4
553	0800–1400, 1/10/58	0.3	0 8	1 2	9.4	0.0	4	7.6	17	0.0			0.02	0.0		38.0	7.0	4	73	5.5
554	1400–1430, 1/10/58	0.5	0.8	0.7	5.5	0.2	2	0.7	11				0.02	0.0		20.0	5.0	4	45	6.3
579	1615, 1/23/58, to 0745, 1/24/58	0.2	0.4	0 0	0.2	0.1	4	0.6	1.2	0 0	0.0	0.1	0.02	0.0	0.00	4.9	1.0	0	4	7.0
580	0745–0900, 1/24/58	0.2	0.8	0 0	0.5	0.4	2	1.0	0.2	0 0	0.0	0.0	0.02	0.1	0.00	4.3	2.0	1	4	6.1
582a	1430–1500, 1/29/58	0.5	0.8	0.5	0 4	0 5	8		3.3				0.01	0 4	0.00	10.0	4 0	0	19	6.4
582b	1500–1530, 1/29/58	0.3	0 8	0 0	0.5	0.3	19†		0.2	0.0			0.03	0.1	0.02	12 0	0.0	0	27	S 5
582c	1530–1600, 1/29/58	0.0	0 8	0.0	0 2	0.1	4	0.4	0.4	0.0			0.02	0.0	0.00	3.9	0.0	0	5	6 7
582d	1600–1620, 1/29/58	0.0	0.0	0,0	0.5	0.5	4		0.2	0.0			0.02	0.0	0.00	3.2	0.0	0	3	6.8
582e	1620, 1/29/58, to 0745, 1/30/58	0.3	6.4	0 5	1.0	0.4	22	1.1	2 7	0.0	0.03	0.0	0.00	0.1	0.00	24.0	18	0	45	7.2
611	0800, 2/4/58, to 1200, 2/5/58	0.4	0.0	0.7	1.5	0.5	2	1.9	3.8	0.05	0.01	0.1	0.04	0.1	0.00	10.0	5.0	2	20	5.9
613	0750–1615, 2/11/58	0.0	0.0	0.2	0 0	0.0	2	0.5	0.2	0.0	0.0	0.0	0.03	0.0	0.12	2.0	1.0	0	5	5.7
616	0750–1015, 2/12/58	0.4	0.8	0 0	0.8	0.2	3	0.0‡	1.3	0 0			0.01	0.1	0.0i	5.0	2.0	0	13	5.5
619	0800–1000, 2/18/58	0.1	0.8	0.0	0.8	0.5	6	0.4	0.4	0.0			0.02	0.0	0.00	6.0	2.0	0	7	6.7
620	1000–1200, 2/18/58	0.7	0.0	0 0	0.3	0.1	5	1.0	0.1	0.0			0 01	0.0	0 04	4.8	0.0	0	3	6.2
621	1500–1600, 2/18/58	0.2	0 0	0 0	1.0	0.8	3	0.0	0.5	0.0			0 01	0.2	0.00	4.2	0 0	0	7	5.4
622	1600–1630, 2/18/58	0.2	0 0	0 0	0.6	0.4	2	0.7	0.0	0.4	0.01	0.0	0.01	0.1	0 02	2 8	0.0	0	4	5.8
624	0800–1335, 2/24/58	1.8	0.0	0 0	0.5	0.2	3	0.4	0.0	0.0	0.01	0.0	0.00	0.0	0.09	4 5	0 0	0	4	6.0
627	1335–1400, 2/24/58	0.0	0.0	0.2	0.5	0.4	3	0‡	0.3	0.4			0.00	0.1	0.09	3.5	1.0	0	6	5.9
631	1400–1430, 2/24/58	0.2	0.0	0.0	0.5	0.2	3	0.3	0.0	0.0	0.03	0.0	0.00	0.0	0.00	2.7	0.0	0	3	5.8
629	1430–1630, 2/24/58	0.1	0.0	0.0	1.0	0.7	3	0.6	0.0	0.0	0.01	0.0	0.00	0.2	0.03	4 1	0 0	0	4	5 8
630	1630, 2/24/58, to 0800, 2/25/58	0.0	0.0	0 0	0.5	0.2	1	0‡	0 3	0.8		0 0		0.1	0.04	2 4	0 0	0	4	5 8
625	1230–1300, 2/25/58	1.0	2.4	1 5	5 9	6.0	22	11	8.8	0.0			0.00	0.7	0.12	48 0	12 0	0	97	6 4
628	1400–1415, 2/25/58	0.0	0.0	1 2	2 0	0.4	3	0‡	3.4	0.8		0.0	0.00	0.1	0.02	9 4	5.0	3	24	5 4

TABLE 1. (Continued)

	Lab. No.	Collection Period	SiO_2	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	HCO_3^{-1}	SO_4^{-2}	Cl^{-1}	F^{-1}	Br^{-1}*	I^{-1}*	NO_2^{-1}	NO_3^{-1}	B	Dissolved Solids Calculated	Hardness as $CaCO_3$	Noncarbonate Hardness as $CaCO_3$	Specific Conductance (micromhos at 25°C)	pH
		Rainwater—Continued																			
	626	1630, 2/25/58, to 0745, 2/26/58	0.0	1.2	1.5	11	0.6	5	0‡	18	0.4		0.0	0.00	0.1	0.03	36.0	9.0	5	82	5.8
	654	0800–0930, 3/2/58	0.0	0.0	1.0	1.4	0.3	4	0‡	2.0	0.4	0.0	0.0	0.02	0.1	0.09	7.3	4.0	1	18	5.7
	648	1330, 3/12/58, to 0800, 3/13/58	0.0	2.0	0.0	3.0	0.6	3	1.7	5.0	0.0	0.06	0.0	0.00	0.1	0.13	14.0	2.0	1	36	6.2
	649	0800, 3/13/58, to 0750, 3/14/58	0.0	2.0	0.0	0.8	0.2	4	1.0	1.6	0.0		0.0	0.00	0.8	0.01	9.3	2.0	1	19	6.1
	650	0950–1145, 3/14/58	0.0	0.0	0.0	0.3	0.0	4	0.6	0.4	0.0	0.06	0.0	0.00	0.1	0.03	3.5	0.0	0	5	5.9
	646	1300–1330, 3/17/58	0.8	2.8	2.2	13	1.0	6	15‡	23	0.0			0.00	0.6	0.12	62.0	16.0	11	102	6.6
	653	1030, 3/20/58, to 0800, 3/21/58	0.0	0.0	0.0	0.7	0.2	3	0.3	1.2	0.0	0.03	0.0	0.00	0.0	0.00	3.9	0.0	0	7	5.8
	657	0800, 3/31/58, to 0800, 4/1/58	0.0	0.0	1.0	1.7	0.3	3	0.9	2.3	0.4	0.0	0.0	0.00	0.1	0.04	8.2	4.0	2	17	5.7
	656	0800, 4/1/58, to 0800, 4/2/58	0.0	0.0	1.7	8.3	0.4	4	4.8	14	0.0	0.1	0.0	0.00	0.2	0.01	32.0	7.0	4	67	5.7
	658	0800–1230, 4/2/58	0.0	0.0	0.5	0.3	0.2	3	0.8	0.4	0.4	0.0	0.0	0.00	0.0	0.04	4.1	2.0	0	6	6.2
1957–1958	662	1230, 4/2/58, to 0800, 4/3/58	0.2	0.4	0.7	2.9	0.2	3	1.2	4.6	0.0	0.03	0.0	0.02	0.1	0.00	12.0	4.0	2	2	6.1
1958–1959	947	1400, 11/13/58, to 0800, 11/14/58	1.1	3.7	0.2	1.7	0.5	10		4.0			0.0				16.0	10.0	2	34	6.3
	948	0800–1215, 11/14/58		2.2	1.5	11	0.6	5		20			0.025	0.00	0.2	0.02	38.0	12.0	8	95	6.3
	987	0845–1130, 1/5/59		0.6	0.2	0.7	0.1	2	1.6	0.5			0.000	0.01	1.4	0.06	6.2	2.3	1	20	5.0
	989	1130–1315, 1/5/59		1.1	0.4	0.6	0.1	2	0.6	0.6			6.7	0.1	0.0	0.00	11	4.4	2	15	5.8
	990	1315–1515, 1/5/59		0.1	0.0	0.3	0.1	2	0.7	0.2			0.000	0.04	0.0	0.00	2.4	0.3	0	5	5.6
	991	1515–1630, 1/5/59		0.1	0.0	0.3	0.0	2	0.7	0.0			0.000	0.03	0.0	0.00	2.1	0.2	0	3	5.6
	992	1630, 1/5/59, to 0750, 1/6/59		0.2	0.3	1.8	0.1	1	1.1	3.0			0.000	0.05	0.0	0.00	7.0	1.8	0	17	5.3
	996	1300, 1/8/59, to 0750, 1/9/59		0.2	0.0	0.1	0.0	2	0.7	0.0			0.000	0.03	0.1	0.03	2.2	0.6	0	5	5.6
	998	0750, 0950, 1/9/59		0.2	0.1	0.0	0.0	1	1.0	0.2			0.000	0.06	0.1	0.00	2.2	0.9	0	7	5.7
	999	0950–1150, 1/9/59		0.3	0.0	0.3	0.0	1	1.0	0.0			0.000	0.05	0.1	0.00	2.2	0.7	0	8	5.0
	1000	1150–1250, 1/9/59		0.2	0.0	0.1	0.0	1	1.1	0.0			0.000	0.04	0.0	0.00	1.9	0.4	0	5	5.1
	1001	1250–1500, 1/9/59		0.1	0.0	0.2	0.2	1	0.9	0.2			0.000	0.04	0.1	0.03	2.3	0.4	0	10	5.0
	1002	1500–1620, 1/9/59		0.1	0.0	0.2	0.2	1	0.8	0.2			0.000	0.05	0.1	0.03	2.2	0.4	0	8	4.9

TABLE 1. (Continued)

Lab. No.	Collection Period	SiO_2	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	HCO_3^{-1}	SO_4^{-2}	Cl^{-1}	F^{-1}	Br^{-1}*	I^{-1}*	NO_2^{-1}	NO_3^{-1}	B	Dissolved Solids Calculated	Hardness as $CaCO_3$	Noncarbonate Hardness as $CaCO_3$	Specific Conductance (micromhos at 25°C)	pH
	Rainwater—Continued																			
1033	1000, 2/8/59, to 1100, 2/9/59		2.9	0.5	2.3	0.1	8	1.4	2.8			0.000	0.07	0.1	0.00	14	9.2	3	33	6.5
1034	1100, 2/10/59, to 1200, 2/11/59	0.1	0.8	0.2	1.2	0.1	3	0.7	2.0	0.01		0.001		0.1	0.06	6.7	2.8	1	14—	6.4
1038	0800, 2/16/59, to 0800, 2/17/59		1.5	1.9	12	0.5	12	2.8	22			0.000	0.07	0.2	0.23	47	11	2	100	6.8
1041	0800–1400, 2/20/59		0.2	0.1	0.0	0.0	1	0.8	0.0			0.000	0.04	0.1	0.00	1.7	1.0	0	4	5.3
1042	1400–1625, 2/20/59		0.0	0.0	0.2	0.1	0	0.4	0.1			0.000	0.05	0.1	0.05	1.0	0.2	0	4	5.1
	Dry Fallout																			
794	7/9/58 to 8/13/58	3.1	12	2.9	2.0	1.0	22	19	2.0		0.0	0.0	0.05	0.6	0.06	53	42	24	85	6.9
795	7/9/58 to 8/13/58	3.1	12	0.5	1.4	0.7	25	14	0.0		0.3		0.09	0.3	0.07	44	32	12	66	6.8
796	7/9/58 to 8/13/58		80	23	8.8	7.8	74	140	33		0.1		0.10	0.3	0.12	330	295	234	555	6.6
797	7/9/58 to 8/13/58		41	14	6.0	6.2	52	65	19		0.3		0.07	0.2	0.08	177	160	118	331	6.5
798	7/9/58 to 8/13/58				5.3	1.9	45	115	14		0.3		0.37	16	0.09				402	6.9
799	7/9/58 to 8/13/58	9.4	29	2.2	2.3	1.0	32	35	3.0		0.2		0.82	1.4	0.02	100	81	56	139	7.0
946	11/10/58 to 11/13/58		10	1.1	1.6	0.5	26	5.8	3.2			0.000	0.00	2.6	0.09	38	30	8	71	7.1
950	11/14/58 to 11/24/58		16	2.8	3.9	1.1	24	21	7.8			0.000	0.01	8.4	0.10	73	51	32	133	6.3
951	11/24/58 to 12/5/58		27	1.5	2.7	1.6	31	30	5.5			0.000	0.00	23	0.08	106	74	48	185	7.0
954	12/5/58 to 12/19/58		18	3.1	1.4	1.2	12	27	3.6			0.000	0.06	21	0.14	81	58	48	144	5.9
1032	1/28/59 to 2/6/59		16	0.9	0.9	0.4	43†	11	1.6			0.000	0.10	1.6	0.04	54	45	8	105	8.5
	Bulk Precipitation																			
544	0800, 12/16/57, to 1100, 12/17/57	0.5	2.0	2.5	15	2.4	1		20				0.28	0.4		44	15	14	121	5.4
550	1630, 12/31/57, to 0800, 1/3/58	2.6	6.4	1.2	0.7	0.0	23	4.0	1.7	0.0			0.00	0.2		28	21	2	58	7.2
555	1430, 1/10/58, to 0930, 1/13/58	1.3	5.6	1.0	10	0.0	11	7.2	20				0.10	2.1		53	18	9	118	6.5
578	1310, 1/22/58, to 1615, 1/23/58	8.7	26	2.9	4.4	1.0	62	22	10				0.01	1.3	0.07	106	76	26	174	6.7
581	0900, 1/24/58, to 0815, 1/27/58	0.3	0.4	1.0	4.0	0.3	8	1.6	4.3	0.0	0.0	0.1	0.00	0.0	0.00	16	5.0	0	36	6.5
583	0745, 1/30/58, to 0930, 2/3/58	0.2	0.4	0.5	0.6	0.1	7	0.8	1.8	0.05	0.00	0.1	0.00	0.5	0.00	8.6	3.0	0	13	6.4

TABLE 1. (Continued)

Lab. No.	Collection Period	SiO_2	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	HCO_3^{-1}	SO_4^{-2}	Cl^{-1}	F^{-1}	Br^{-1}*	I^{-1}*	NO_2^{-1}	NO_3^{-1}	B	Dissolved Solids Calculated	Hardness as $CaCO_3$	Noncarbonate Hardness as $CaCO_3$	Specific Conductance (micromhos at 25°C)	pH
	Bulk Precipitation—Continued																			
610	0930, 2/3/58, to 0745, 2/4/58	2.0	3.2	1.5	2.5	0.4	9		6.4				0.00	0.5	0.00	21	14	7	45	5.6
612	1230, 2/5/58, to 1030, 2/7/58	0.5	0.0	0.5	0.2	0.1	3	0.9	0.05	0.7	0.01	0.0	0.02	0.1	0.00	4.6	2.0	0	14	5.6
618	0800, 2/14/58, to 0800, 2/18/58	2.0	6.4	1.5	0.7	0.8	20	5.3	1.3	0.0			0.00	3.0	0.04	31	22	6	54	6.7
623	1630, 2/18/58, to 0800, 2/24/58	6.9	29	7.5	7.5	2.4	40	50‡	12	0.5			0.00	20	0.11	205	103	71	261	6.8
645	0800, 3/7/58, to 0745, 3/10/58	2.2	4.4	1.7	12	1.0	2	15‡	18	0.9			0.02	6.0	0.09	64	18	17	123	6.4
644	0745, 3/10/58, to 0930, 3/12/58	1.6	2.4	1.5	4.1	0.5	7	2.6	6.0	0.0	0.07	0.0	0.00	1.3	0.01	23	12	7	44	6.3
651	1145, 3/14/58, to 0800, 3/17/58	0.0	0.0	0.0	0.3	0.2	3	0.6	0.5	0.0	0.06	0.0	0.00	0.2	0.04	3.4	0.0	0	7	5.4
652	0800, 3/17/58, to 0750, 3/20/58	0.0	0.0	0.0	0.3	0.2	6	0.9	0.2	0.0	0.02	0.0	0.00	0.3	0.01	4.9	0.0	0	12	6.1
723	4/3/58 to 6/2/58	4.8	9.6	3.9	1.4	0.7	52	1.4	2.2	0.6	0.1	0.4	0.02	0.1	0.12	53	40	0	91	6.7
769	6/2/58 to 6/9/58	0.7	1.2	0.7	0.6	0.3	7	1.3	0.8	0.0	0.0	0.0	0.03	0.4	0.00	9.5	6.0	1	17	6.0
770	1000, 6/9/58, to 0800, 7/1/58	6.3	24	9.7	11	2.9	74	26	24	0.0	0.0	0.2	0.03	0.2	0.10	143	100	39	252	7.0
777	0800, 7/1/58, to 0800, 7/17/58	15	57	24	11	2.7	116	106	30				0.00	21	0.12	324	243	146	540	7.1
926	11/5/58 to 11/10/58		9.7	7.6	1.8	0.4	18	15	3.0			0.005	0.01	4.4	0.03	46	35	20	91	6.5
955	12/19/58 to 12/22/58		0.6	0.8	0.1	0.3	3	2.9	0.2			0.005	0.00	1.0	0.00	7.4	4.6	3	19	5.6
981	12/22/58 to 1/5/59		3.9	0.4	0.6	0.1	10	2.8	1.4			0.000	0.00	0.4	0.00	14	11	3	25	6.3
1021	1/9/59 to 1/28/59		24	2.2	4.4	0.6	70	9.9	8.2			0.000	0.00	0.1	0.02	83	68	12	163	8.0
1037	2/11/59 to 2/16/59		0.9	0.3	0.8	0.1	5	0.4	1.2			0.000	0.00	0.0	0.02	6.1	3.7	0	13	6.4
1039	2/17/59 to 2/18/59		0.6	0.9	2.6	0.1	3	1.5	5.5			0.000	0.08	0.1	0.00	13	5.2	3	26	5.9
1040	2/18/59 to 2/20/59		1.0	0.3	1.9	0.1	3	1.7	2.9			0.000	0.13	0.3	0.00	9.8	4.0	1	25	6.0

* Because of the sensitivity ranges of analytical methods used, and the very dilute character of the waters analyzed, these values reported for iodide and bromide are considered indicative only. They are not intended to express absolute concentrations, nor even necessarily to show the presence of the ion in the sample. The values do, however, set an upper concentration limit, equivalent to the sensitivity of the analytical method, and they show that the ions were not present in quantities exceeding those limits. Values for iodide reported to 0.001 are considered reliable.

† Includes 2 ppm CO_3 as HCO_3.

‡ Turbidimetric SO_4.

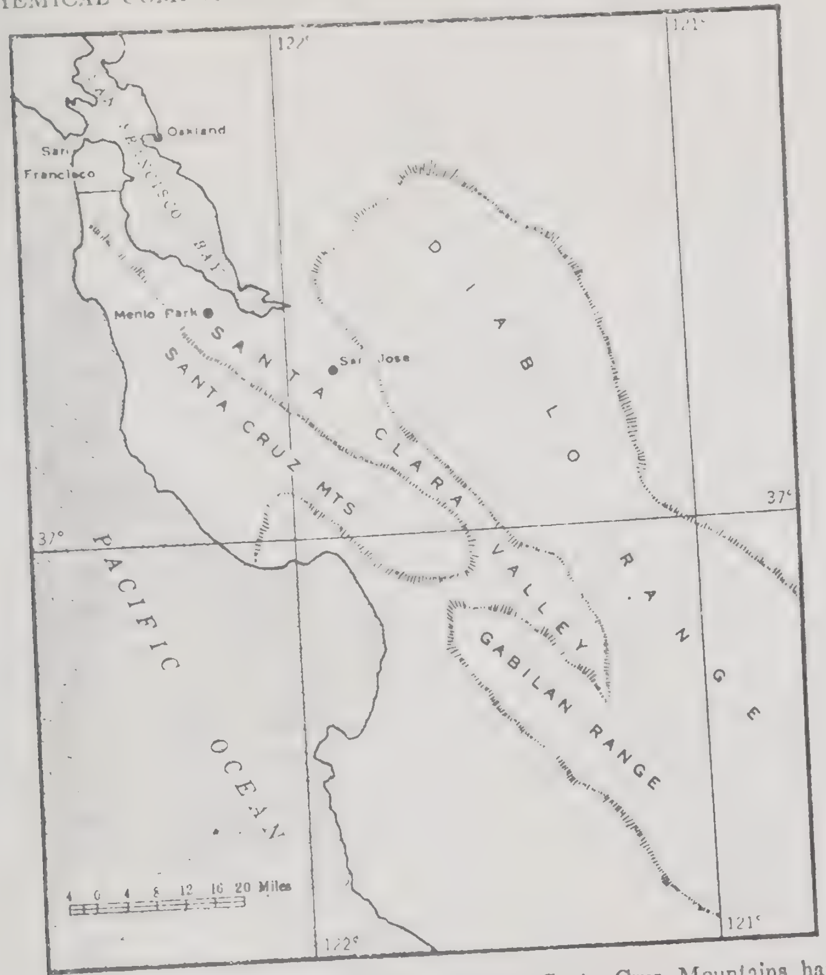

Fig. 1. The San Francisco Bay area, California. The Santa Cruz Mountains have maximum elevations of about 2000 feet, the Diablo Range about 4000 feet.

on the triangular coordinates, lower left. The anion percentages are separately plotted on the triangular coordinates, at the right on the diagram. The positions of the two points are next projected into the diamond-shaped grid and a point is marked at the intersection of the lines of projection. Each sample, then, is represented by three points: one in the cation triangle, one in the anion triangle, and one in the diamond. The position of a point in the central diamond gives a general indication of the chemical composition of a particular sample [*Piper*, 1945]. Recognizable differences appear not only among the three phases of precipitation but also between individual samples within a single phase.

Statistical comparison (Table 2) shows that variations of the mean concentrations of the major constituents in rainwater between 1957–1958 and 1958–1959 may be the result of chance. In contrast, comparison of the mean concentrations of the major constituents in rainwater and in bulk precipitation, respectively, show statistically significant differences throughout, but particularly with respect to silica, magnesium, bicarbonate, nitrate, and dissolved solids. The comparison was made between the mean value for bulk precipitation and the larger of the two annual mean concentrations in rainwater.

Dry fallout cannot be compared in the same way, for reasons stated in the definition of this phase of precipitation. Examination of analyses reported in Table 1, and of Figure 4, however,

TABLE 2a. Ranges in Concentration of Selected Constituents in Rainwater and Bulk Precipitation, and Comparisons of the Means

Constituent	Rain 1957–1958 Max.	Median	Min.	Mean	Rain 1958–1959 Max.	Median	Min.	Mean	Bulk Precipitation Max.	Median	Min.	Mean
Silica (SiO_2)	1.8	0.2	0.0	0.29	1.1	*	0.1	*	15	1.8	0.0	3.17
Calcium (Ca^{+2})	6.4	0.4	0.0	0.77	3.7	0.2	0.0	0.80	57	3.2	0.0	6.70
Magnesium (Mg^{+2})	2.2	0.0	0.0	0.43	1.9	0.1	0.0	0.30	21	1.2	0.0	2.96
Sodium (Na^{+1})	13	0.8	0.0	2.21	12	0.3	0.0	1.83	15	1.8	0.1	3.94
Potassium (K^{+1})	1.2	0.4	0.0	0.35	0.6	0.1	0.0	0.15	2.9	0.3	0.0	0.71
Bicarbonate (HCO_3^{-1})	22	3	1	4.95	12	2	0	3.06	116	8	1	22.5
Sulfate (SO_4^{-2})	15	0.7	0.0	1.76	2.8	0.8	0.4	1.02	106	2.8	0.4	12.2
Chloride (Cl^{-1})	23	1.2	0.0	3.76	22	0.2	0.0	3.10	30	3.0	0.2	7.28
Nitrite (NO_2^{-1})	0.04	0.01	0.00	0.011	0.10	0.045	0.00	0.046	0.28	0.00	0.00	0.028
Nitrate (NO_3^{-1})	0.8	0.1	0.0	0.15	1.4	0.1	0.0	0.16	21	0.4	0.0	2.56
Dissolved solids (calculated)	62	7.8	2.0	12.4	47	2.4	1.0	9.70	324	23	3.4	52.9
*p*H	8.5	5.95	5.4		6.8	5.6	4.9		8.0	6.4	5.4	

* Only two samples analyzed.

show the degree to which Ca^{+2}, Mg^{+2}, and SO_4^{-2} dominate the chemical makeup of this phase. The small number of samples of dry fallout collected and analyzed are probably representative of this phase in Menlo Park because the larger group of samples of bulk precipitation indicates the combination with rainwater of substances having high concentrations of Ca^{+2}, Mg^{+2}, and SO_4^{-2}.

There are numerous industries in areas near Menlo Park that doubtless influence the chemical composition of the dry fallout. Gypsum and other products are processed about 6 miles east of Menlo Park. And within 10 miles both to the north and the south, cement is manufactured. These and other industries presumably contribute a major part of the calcium to the dry fallout. According to local estimates [*Bay Area Air Pollution Control District*, 1958], more than 550 tons of sulfur dioxide are released into the air every day in the San Francisco Bay area. Combination of these two chemical species in the air, on the collector, or in solution in the collection vessel produces a calcium sulfate water, the carbonate minerals doubtless adding to the bicarbonate concentrations observed.

In the samples collected, bulk precipitation most nearly reflects the properties of the local dry fallout, tending toward a calcium and bicarbonate or sulfate composition. However, the influence of the ocean and San Francisco Bay is seen in the trend of some of the samples of bulk precipitation toward a sodium chloride composition. The general chemical content of rainwater at Menlo Park is relatively constant from year to year, but it definitely varies during each rainy season. Variations in the chemical composition from rainstorm to rainstorm, and even within a single rainstorm (see analyses 580, 582*a*, *b*, *c*, *d*, *e*, 947, and 948, Table 1) are quite likely to arise in part from increments of locally derived mineral constituents.

Minor constituents. Several minor constituents—silica, boron, fluoride, bromide, iodide, nitrite, and nitrate—are reported in Table 1. No noteworthy trends were observed in these minor constituents, with the exception of nitrate, which was considerably higher in dry fallout than in the other two phases. Measurements of *p*H are also shown.

We recognize that the *p*H tends to change during storage of water samples, that the tendency toward change is especially noticeable in water of small mineral content where little or nothing is present to buffer the solution, and that the amount and direction of *p*H change is unpredictable for any single water sample. The values reported are those read at the time of analysis of the samples. They probably do not accurately represent the *p*H of the rain or bulk precipitation at the time of the rainfall.

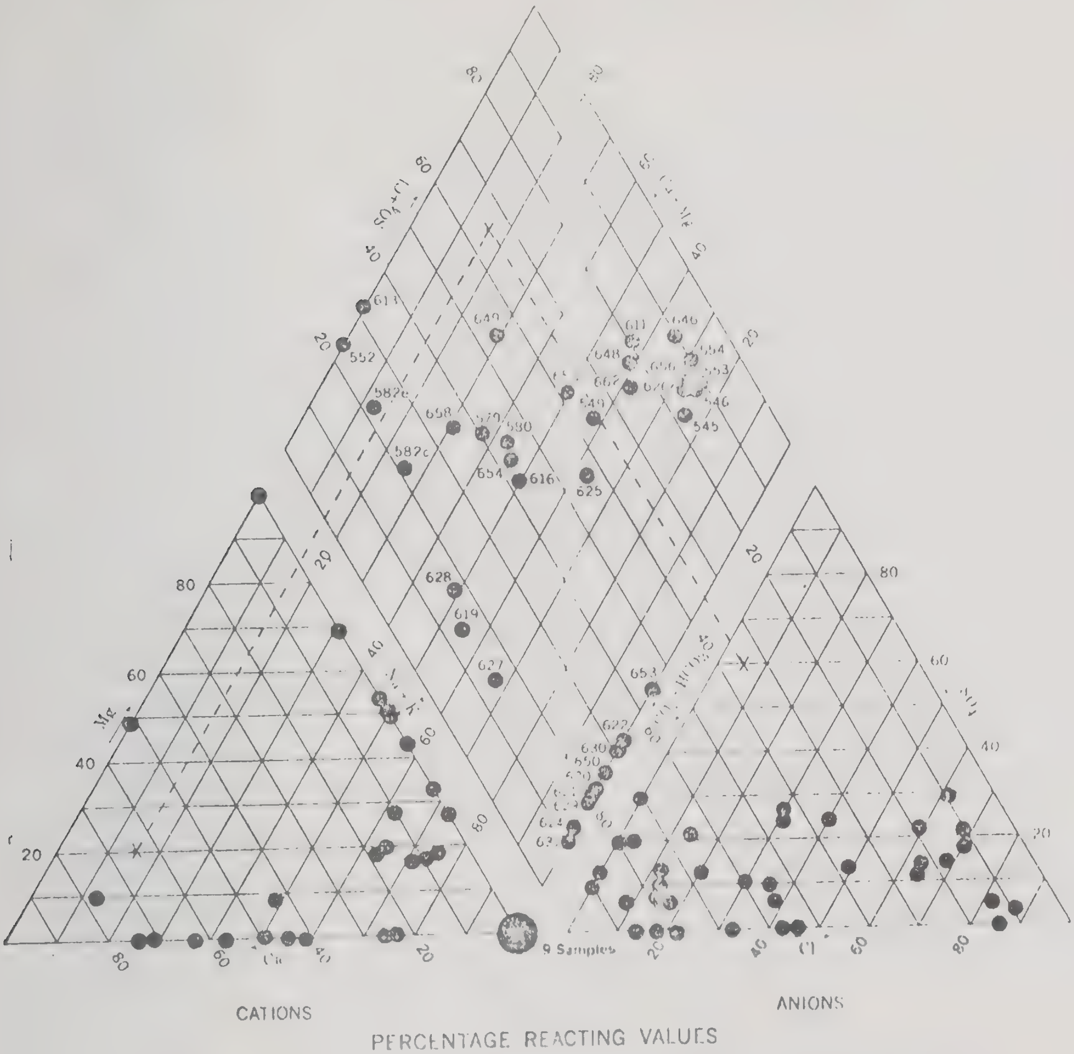

Fig. 2. Diagram showing general chemical composition of rainwater at Menlo Park, Calif., 1957–1958. Numbers refer to analyses in Table 1. Method of plotting points is illustrated by a hypothetical analysis (X). The left-hand triangle shows that Ca^{+2} makes up 65% of the cation equivalents, Mg^{+2} 20%, and (Na^{+1} + K^{+1}) 15%. The right-hand triangle shows 35% (HCO_3^{-1} + CO_3^{-2}), 60% SO_4^{-2}, and 5% Cl^{-1}. By projection (dashed lines) the position of X in the summary (diamond) diagram is determined. The general chemical composition of sample X appears in the central diamond as primarily alkaline-earth cations and strong-acid anions.

Precipitation in Other Areas

At Menlo Park the differences in mean concentration between rainwater and bulk precipitation are statistically significant (Table 2*a* and *b*). Bulk precipitation is on the average about 4 to nearly 10 times higher in concentration than rainwater is. A combination of oceanic and local influences—largely industrial in origin—is invoked to explain observed variations. The next logical question is to what extent these differences can be found in places other than Menlo Park. What, for example, is the circumstance with reference to rural areas and to areas in humid climates?

Published information from other studies implies that, wherever sampled, bulk precipitation

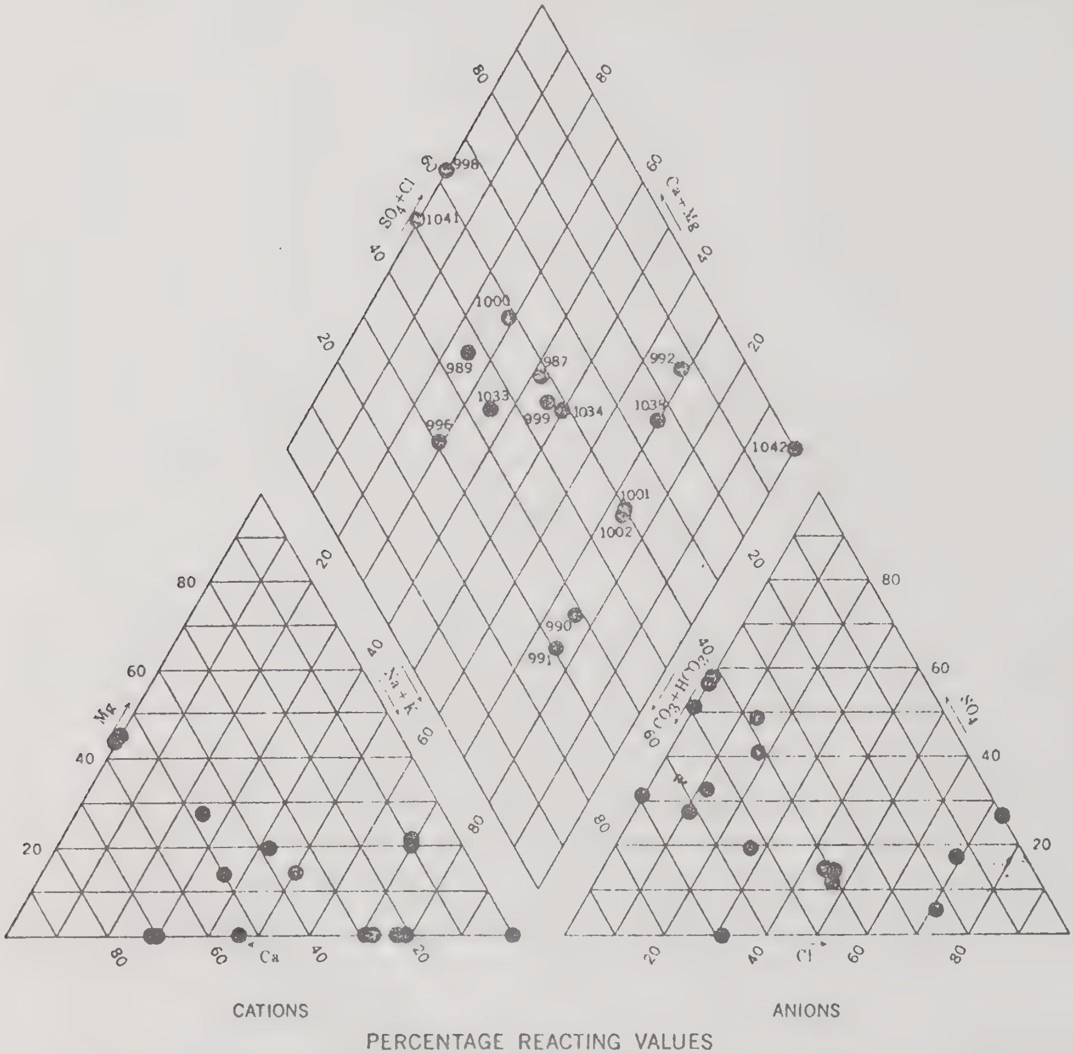

Fig. 3. Diagram showing general chemical character of rainwater at Menlo Park, Calif., 1958–1959. Numbers refer to analyses in Table 1.

contains more dissolved mineral substance than rainwater does. Dry fallout appears to add mineral constituents to snow also. Detailed comparisons and firm conclusions, however, are not feasible because of the diversity in methods of sampling and chemical analysis of precipitation.

We have found no two studies of the chemistry of precipitation that are identical with respect to methods of collection and analysis of samples—and none that are specifically comparable with our procedures. A few examples will illustrate both the trend of results and the problems involved in making comparisons.

The U. S. Air Force Air Research and Development Command study of 1955–1956 was designed [*Junge and Gustafson*, 1957] 'to be identical with that of the Scandinavian and European network, so as to make the results comparable, . . . with the exception of the protection of the funnel in dry weather.' In terms of the present paper, then, Junge and his co-workers sampled rain, and the Northern European network sampled bulk precipitation. Neither network reports sampling the two phases separately, except that *Junge and Gustafson* [1957] report 'tests near Boston, Massa-

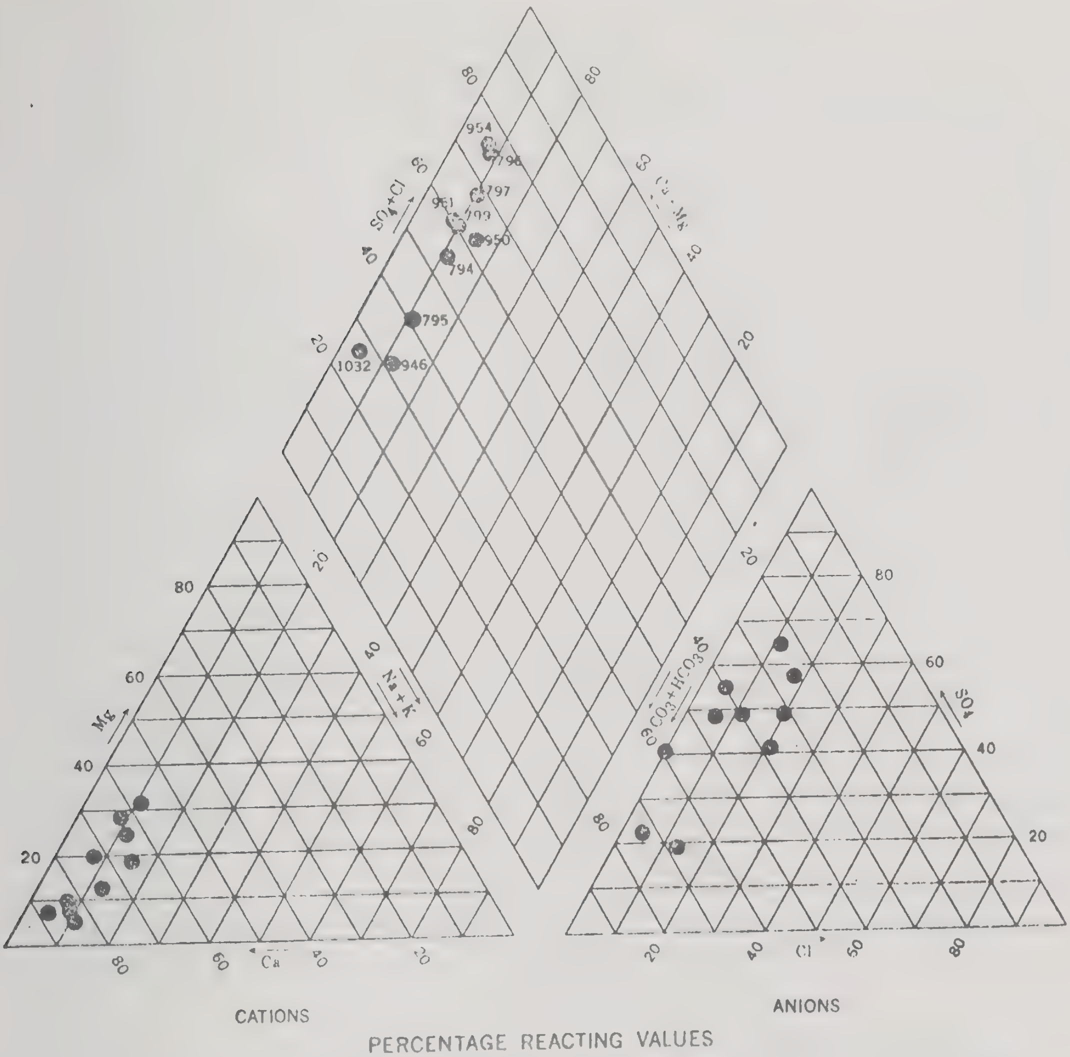

Fig. 4. Diagram showing general chemical character of dry fallout at Menlo Park, Calif., 1957–1959. Numbers refer to analyses in Table 1.

chusetts, where two collectors were exposed side by side; one open in precipitation only, and the other open continuously. On the average, the open gage collected twenty-five per cent more Cl^{-1} as a result of the dry fallout.' The Boston station is located in a humid climate but is certainly in the range of urban and industrial contaminants.

The fact that the United States network samples represent rain and the Northern European network samples bulk precipitation suggests that comparison be made of the results obtained in the two programs. Again, certain mechanical difficulties arise. Results from the United States network have been reported [*Junge and Werby*, 1958] only as annual average concentrations plotted on maps. The Northern European network results have been presented largely as tabulations of data (monthly samples) in various issues of *Tellus* [see *Svenska Geofysiska Föreningen*, 1955, 1956], or in interpretive studies [*Rossby and Egner*, 1955; *Eriksson*, 1955, 1959, 1960]. Further compilation and interpretation of these extensive collections of data are in progress (Svante Odén, 1962, written communications).

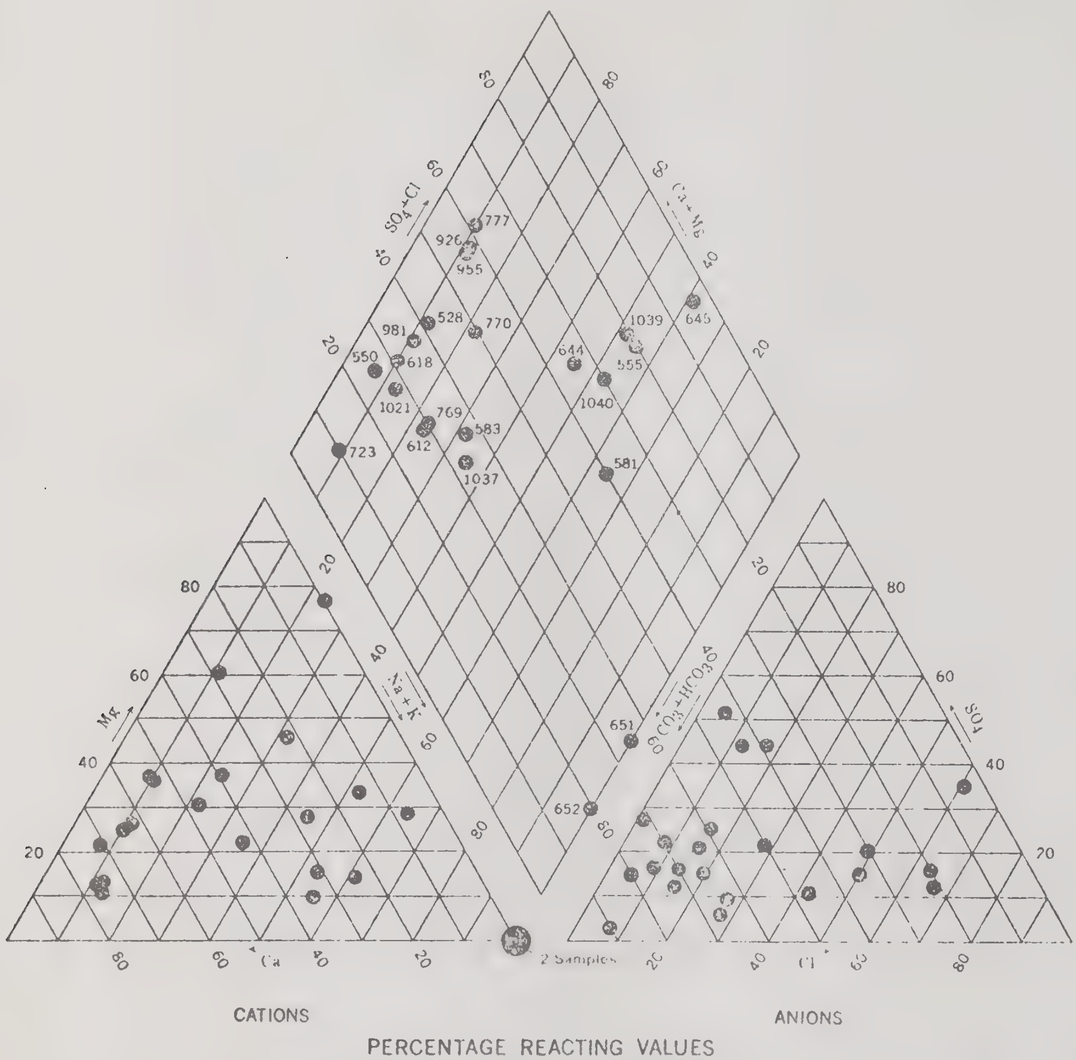

Fig. 5. Diagram showing general chemical character of bulk precipitation at Menlo Park, Calif., 1957–1959. Numbers refer to analyses in Table 1.

For the present, then, it seemed desirable to make a comparison on a limited scale only. Stations in the Northern European network were selected from their locations given by map [*Egner and Eriksson*, 1955] and coordinates [*Svenska Geofysiska Föreningen*, 1956] to give reasonable distribution between coastal and inland areas. Seven coastal and nine inland stations were selected. Monthly average concentrations of sulfate, chloride, sodium, and calcium were calculated in terms of ppm (the values are reported as mg/m²) and averaged for the year, July 1955 to June 1956 to coincide with the sampling period used by Junge and Werby. The results are reported in Table 3, where they are compared with United States network data.

Insofar as the data are representative of rain and bulk precipitation, respectively, there is strong indication that bulk precipitation—wherever and however sampled—is indeed more concentrated overall than rainwater. Because of uncertainty regarding the representativeness of the Northern European stations selected for this comparison, and regarding the effects of concentration by evaporation in the month-long period during which these samples some-

TABLE 2b. Significance of Differences of the Means*

Constituent	Rain 1957–1958 versus Rain 1958–1959	Bulk Precipitation versus Rain 1957–1958	Bulk Precipitation versus Rain 1958–1959
Silica (SiO_2)	Not compared; only 2 determinations made of SiO_2 in 1958–1959 rainwater.	Significance >0.01	
Calcium (Ca^{+2})	Not significant at 0.10 level		Significance >0.10 <0.05
Magnesium (Mg^{+2})	Not significant at 0.10 level	Significance >0.01	
Sodium (Na^{+1})	Not significant at 0.10 level	Significance >0.10 <0.05	
Potassium (K^{+1})	Not significant at 0.10 level		Significant at 0.05 level
Bicarbonate (HCO_3^{-1})	Not significant at 0.10 level	Significance >0.01	
Sulfate (SO_4^{-2})	Not significant at 0.10 level	Significance >0.10 <0.05	
Chloride (Cl^{-1})	Not significant at 0.10 level	Significance >0.10 <0.05	
Nitrite (NO_2^{-1})	Significance >0.01	Significant at 0.10 level	
Nitrate (NO_3^{-1})	Not significant at 0.10 level	Significant at 0.01 level	
Dissolved solids (sum)	Not significant at 0.10 level	Significance >0.01	

* These comparisons were made using Student's t test [*Dixon and Massey*, 1957, p. 119].

TABLE 3. Comparison of Yearly Average Concentrations of Four Constituents in Rain in the United States and in Bulk Precipitation at Selected Northern European Network Stations, July 1955 to June 1956*

	Concentrations, ppm															
	Coastal Areas								Inland Areas							
	U. S. A. stations				N. European stations				U. S. A. stations				N. European stations			
	Max.	Mean	Min.	No. of Stations	Max.	Mean	Min.	No. of Stations	Max.	Mean	Min.	No. of Stations	Max.	Mean	Min.	No. of Stations
Sulfate (SO_4^{-2})	10.7	2.45	0.99	16	6.97	4.38	1.08	7	4.76	2.14	0.69	45	10.74†	5.37	1.28	9
Chloride (Cl^{-1})	22.6	4.83	0.35	17	33.2	7.22	1.22	7	0.68	0.22	0.08	45	9.35	2.57	0.52	9
Sodium (Na^{+1})	22.3	3.68	0.23	16	17.7	3.84	0.66	7	4.83	0.42	0.10	47	3.55	1.22	0.48	9
Calcium (Ca^{+2})	1.45	0.58	0.25	15	2.65	1.64	0.45	7	4.74	1.41	0.30	48	3.55	1.54	0.28	9

* Data for stations in the United States from *Junge and Werby* [1958]; stations in Northern European network from *Svenska Geofysiska Föreningen* [1955, 1956]. Values recalculated from mg/m² to ppm; SO_4^{-2} further recalculated from reported S.

† Station Kvarntorp (Kv), 'one kilometer from a slate-burning plant' has following yearly averages (1955–1956 data): SO_4^{-2}, 56.5 ppm; Cl^{-1}, 2.15 ppm; Na^{+1}, 2.48 ppm; Ca^{+2}, 24.0 ppm. This station is not included in the values tabulated.

times stand in the collecting vessel, the means were not compared statistically.

The chloride content of 'rain' and 'snow' in West Germany was reported by *Menzel* [1948]. Collection procedures were not described. On Donnersberg, the Cl^{-1} content of 59 samples of snow ranged from 1.59 to 30.97 ppm and averaged 8.12 ppm. Thirty-seven samples of rain yielded a minimum of 1.01, a maximum of 10.41, and an average of 4.46 ppm. Menzel attributes the higher concentrations of chloride to industrial pollution. At Haid, where Menzel believed industrial pollution to be absent or negligible, nine samples of snow showed contents of Cl^{-1} ranging from 1.93 to 25.90 ppm. The average is 5.90 ppm. In 51 samples of rain, the Cl^{-1} ranged from 0.37 to 28.86 ppm and averaged 4.30 ppm. The concentrations reported exceed those in the group of Northern European network stations averaged and reported in Table 3 of this paper. The Donnersberg and Haid samples are probably bulk precipitation.

The variation in concentration of constituents during a single snowfall with time and microenvironment is reported by *Batta and Leclerc* [1934]. Those authors took a group of snow samples in and near Liege, Belgium, after a 3-hour snowstorm on February 18, 1933. In 16 samples, the SO_4^{-2} content (calculated from the SO_3 reported) ranged from 1.5 to 80.4 ppm. The average was 23.64 ppm. In each of two localities, two samples were taken—the first shortly after the snowfall, the second 24 hours later. In the one pair, the initial concentration of SO_4^{-2} was 10.8 ppm; that a day later was 14.2. In the other locality, the concentration increased from 69.8 to 80.4 ppm. The addition of combined sulfur by dry fallout seems clear.

The range of Cl^{-1} concentration in the same snow samples was from 4.6 to 14.2 ppm, the average 8.6. The paired samples showed increases during the 24-hour period, from 5.3 to 7.4 ppm at one place and from 8.8 to 12.4 ppm at the other. The chloride in the snow was attributed to use of HCl in industrial processes in the area. The possibility of concentration by evaporation or sublimation, however, should be borne in mind.

Conclusions

By appropriate collection procedures, significant differentiation was made between three phases of precipitation. Dry fallout mainly reflected contributions from local sources, some of them industrial. Rainwater showed most nearly the marine effect but was not purely marine in character. Bulk precipitation represented a mixture of these two.

Bulk precipitation contained 4 to 10 times more mineralization than the rainwater. Apparently, the major portion of this mineralization was derived from the accumulation of dry fallout on the collector. The contribution of rain and dry fallout to bulk precipitation was controlled in part by the microclimatic conditions. The presence or absence of a temperature inversion served largely to segregate the two influences, continental and marine. Bulk precipitation is considered the most significant phase in studying the contribution of atmospheric mineralization to the chemical quality of natural water.

Comparison with published data suggests that, wherever and however sampled, bulk precipitation generally contains more dissolved mineral matter than rainwater does. Lack of uniformity in methods of sampling and analysis preclude detailed evaluation of the results obtained in different studies. Worldwide uniformity in methods of collection and analysis of samples is probably not feasible, but it remains an obligation on the part of all workers in this field to report in detail the methods that are used.

Very few previous attempts have been made to examine more than one phase of precipitation. None are known that have as large a suite of samples for comparison of the different phases of precipitation as is given in Table 1, or as detailed analyses for minor constituents. The evidence derived in the present study indicates that the distinction should be made—and comparison samples of the three phases taken—at many points throughout the world so that the differences among the phases can be evaluated from an adequate base of data.

As work progresses—especially in the field of chemical weathering—the importance of determinations of silica, boron, iron, and other minor constituents will increase. The spectrum of constituents sought should be steadily enlarged.

Acknowledgments. We gratefully acknowledge the analytical work of our colleagues in the Geological Survey at various times, J. P. Schuch, S. M. Rogers, C. E. Roberson, and C. G. Mitchell.

Thanks are also due Elmer Robinson of the Stanford Research Institute, who reviewed the manuscript in an early stage of its preparation.

Publication authorized by the Director, U. S. Geological Survey.

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(Manuscript received January 3, 1964; revised May 6, 1964.)

SR/Tech Memo 7/April 4, 1977
J. Eilers/S. Goldman

SURFACE RUNOFF MANAGEMENT PLAN

GUIDANCE FOR IDENTICATION AND RANKING OF SURFACE RUNOFF POLLUTION PROBLEMS

TECHNICAL MEMORANDUM NO. 7

APRIL 4, 1977

A. Introduction

Technical Memorandum No. 5 provided the counties with criteria for water quality problem identification. These criteria included comparison of past and present water quality data with:

- data on water quality runoff from virgin land
- State water quality standards and beneficial uses
- national data on quality of surface runoff
- national data on pollutant concentration in effluents from point sources.

The unforeseen delays in making this technical memorandum available to the counties reduced its potential usefulness in preparing the county progress reports addressing the existing water quality problems. Ranking of water quality problems is of particular importance for making decisions regarding:

- what level of effort is needed to adequately address the nonpoint source pollution problems
- which nonpoint source pollution problems should be addressed first.

The main emphasis in this technical memorandum is placed on comparison of pollutant loads from point sources with MAC model outputs and county monitoring data. It is hoped that the information contained in this technical memorandum and in Technical Memorandum No. 5 will be helpful in further county work on water quality problem identification.

B. Comparison of Nonpoint Source Pollution with Point Source Pollution

In the Bay Area, present point source pollution is estimated to exceed nonpoint source pollution on an annual basis (see Table 4, Progress Report No. 2). The major exception to this occurs with sediment loads, where nonpoint source loads exceed point source loads. Future control of point sources is expected to reduce these pollutants loads. At the same time, nonpoint source pollution is expected to increase. Figure 1 illustrates a hypothetical case.

COMPARISON OF POINT AND NONPOINT POLLUTION
LOADS FROM MAC WATERSHED X (AND COUNTY)

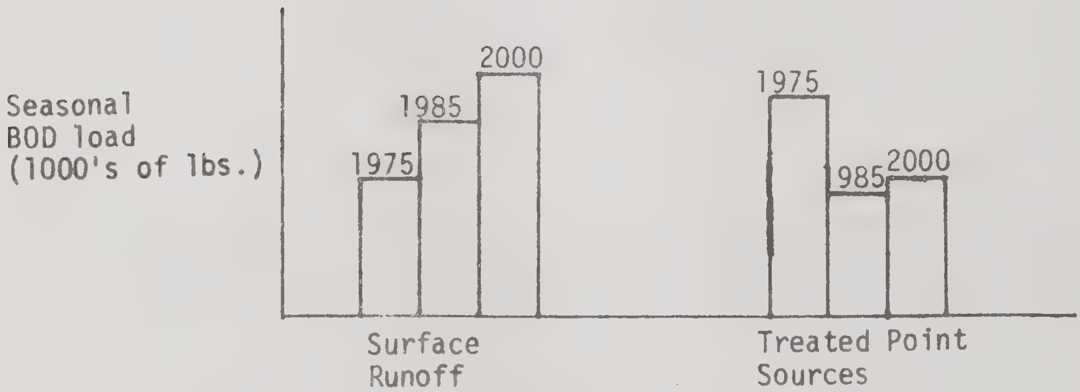


Figure 1

This type of comparison, however, presents only a coarse look at the total pollutant loads. A more detailed examination of the nonpoint pollution problem can be initiated by comparing the treated point source loads with the MAC land use categories. An example of this approach is given in Figure 2.

COMPARISON OF SUB-AREA POLLUTION LOADS
FROM MAC WATERSHED X (AND COUNTY)

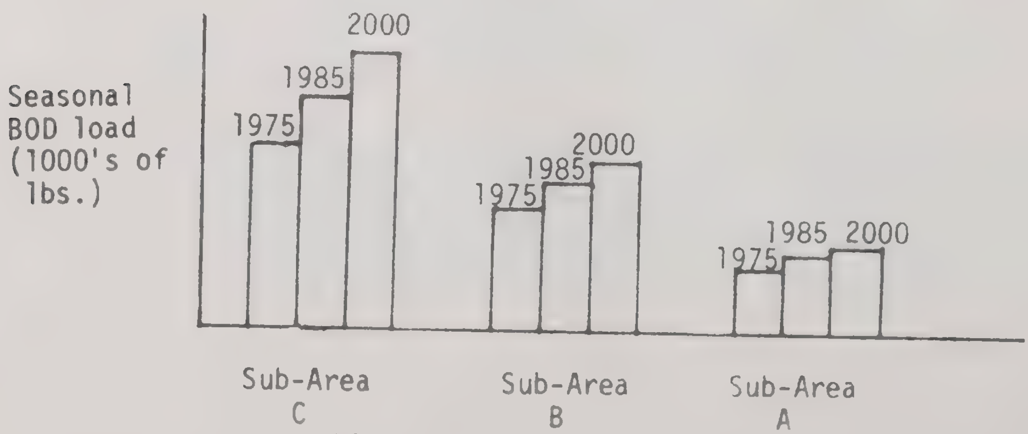


Figure 2

Comparing nonpoint with point source pollution on an annual basis is not entirely satisfactory since the storm loads occur only during the rainy season. Therefore, it is recommended that point/nonpoint comparisons be made during the rainy months. An average monthly distribution of precipitation in the Bay Area is shown in Figure 3. It is apparent from this diagram that 90% of annual rainfall occurs in the period November through April. Thus, for purposes of comparison with point sources it will be assumed that the entire annual surface runoff loading occurs within a six-month period.

Mean Monthly Distribution of Precipitation[1]

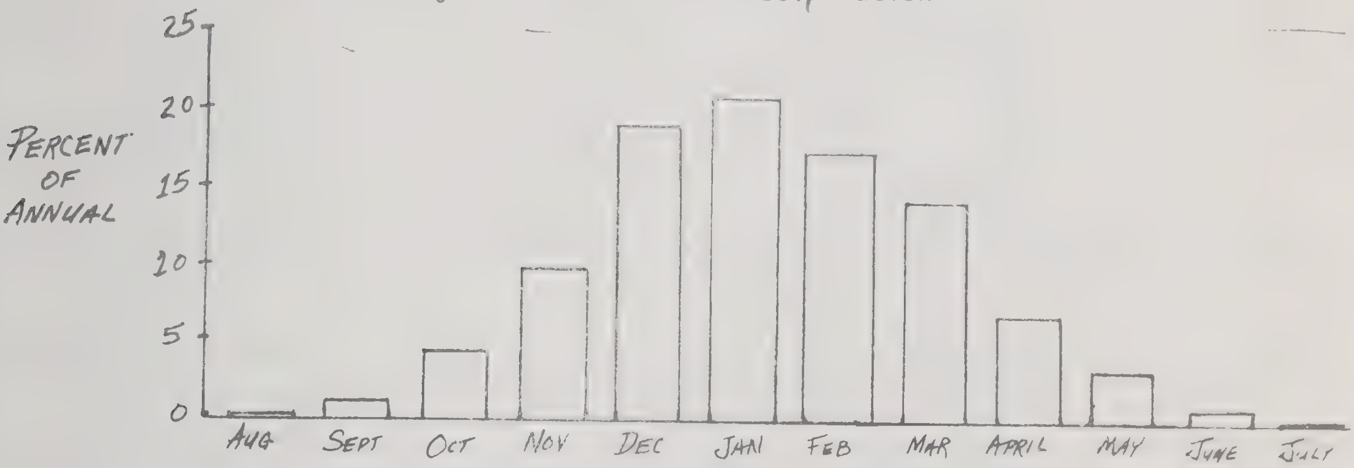


Figure 3

Comparing sources of water pollution over various time periods will reveal important differences between nonpoint and point source pollution. Similarly, these sources can be evaluated by comparing their respective pollutant loadings and concentrations.

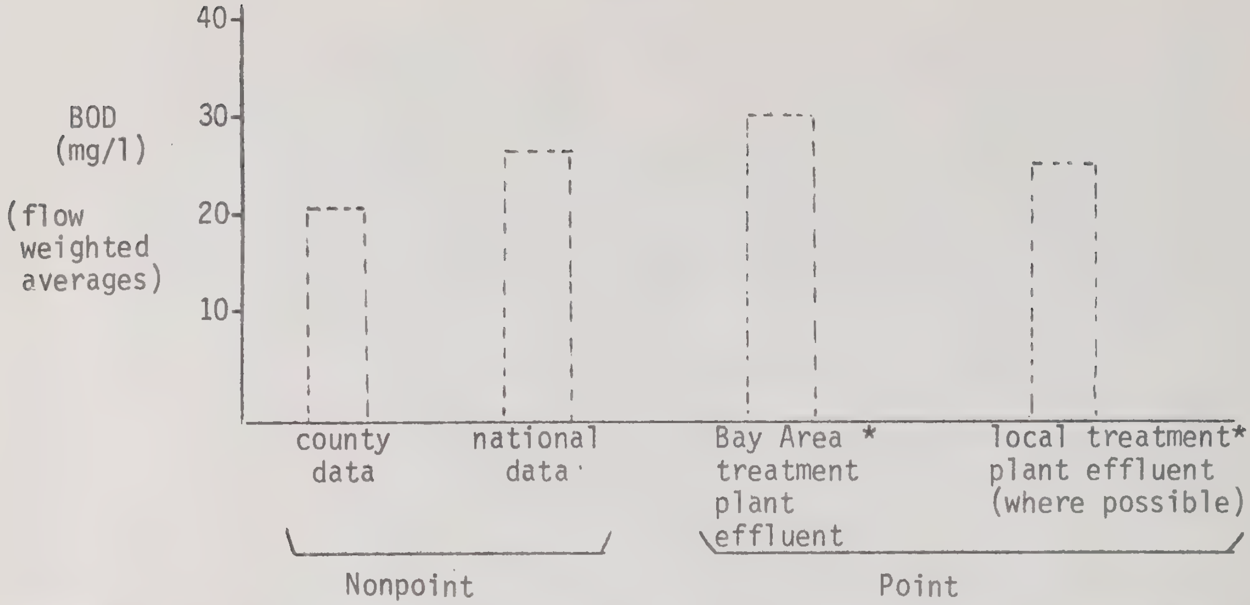
C. Comparison with Effluent Pollutant Concentrations

Comparison of nonpoint sources with effluent pollutant concentrations can be performed using data from county monitoring programs. Figure 4 consists of four bar diagrams showing average BOD concentrations from the following:

- county monitoring data
- county watershed pollutant concentrations based on national coefficients
- average Bay Area treatment plant effluent
- local treatment plant effluent

[1] Rantz, S.E., 1971, "Mean Annual Precipitation and Precipitation Depth-Duration Frequency Data for the San Francisco Bay Region, California," Open-File Report, U.S. Geological Survey.

FIGURE 4



*Values from point sources should be taken from same month as county monitoring data

These diagrams could also be prepared for suspended solid, total nitrogen and total phosphorus. The counties may wish to include additional diagrams for other parameters which have special significance for their localities. The national data bar diagram represents the pollutant concentrations derived using runoff coefficients from the MAC model. These values are multiplied by the percentage of land uses within the sampled watershed. The products are then summed to yield a total value for the concentration of the respective pollutant (see example below). The national quality constants from the MAC model are shown in Table 1.

Table 1

MAC QUALITY CONSTANTS FOR CONCENTRATIONS FROM SEPARATE SEWER SYSTEMS (in mg/1)

Land Use	BOD	TN	TP	SS
Residential	10.4	7.01	0.44	211.5
Commercial	41.5	3.84	0.98	288.1
Industrial	15.8	3.58	0.91	377.6
Open Space	1.5	0.79	0.13	35.0

Example of Substituting National Data in Sampled Watershed (BOD)

County XXX Watershed 02

Land Use	% of Total Area	x	Coefficient	
Residential	50 (.50)	x	10.4	= 5.2
Commercial	5 (.05)	x	41.5	= 2.1
Industrial	5 (.05)	x	15.8	= 0.8
Open Space	40 (.40)	x	1.5	= 0.6

8.7 mg/1 BOD

D. <u>Comparison of Pollutant Mass Loads from Nonpoint and Point Sources by MAC Watershed</u>

The next technique for comparing nonpoint with point source pollution is by calculating the mass pollutant loading from both sources. Point source loadings from municipal and discrete industrial dischargers are provided in the Water Quality Management Plan's Technical Memorandum No. 12. These values are for base year 1975. The data is organized on a geographical basis by Sewerage Units. The point source totals can be obtained by summing the municipal loads and the discrete industrial loads (Table 2, Tech. Memo 12) within each sewerage unit.

The nonpoint sources are to be estimated by MAC watersheds. Difficulties arise in this analysis since there is seldom an exact correspondence between these two divisions. The suggested MAC groupings for this analysis are provided in Table 2. Counties may modify these groupings if further analysis indicates a more satisfactory approach. These comparisons can also be made for 1985 and 2000 using information provided by ABAG. An example of this comparison is given below.

<u>Example of Point/Nonpoint Comparison by MAC Groupings (Using NAPA County) for BOD</u>

Point Sources (Municipal and Industrial) from Tables I & II, Tech. Memo No. 12.

Municipal Treated Waste Loads (Table I)
Sewerage Unit 11, Napa-American Canyon
BOD 1.266 LB/day x 180 days = 228,180 lbs.

Discrete Industrial Waste Loads (Table II)
Sewerage Unit 11, Kaiser Street Corp.
BOD 20 lb/day x 180 days = 3,600 lbs.

Point Source Loading = 231,780 lbs/rainy season

Nonpoint Sources

Surface Runoff - MAC output

Upper Napa River Middle Napa River American Canyon	Add annual BOD_5 loading from each Watershed. (Annual surface runoff equivalent to six-month rainy season).

Table 2

COUNTY	WATERSHED NAME	COUNTY	WATERSHED NAME
Alameda	Berkeley Lake Merritt San Leandro Upper San Leandro (Contra Costa)	Napa	Upper Napa River Middle Napa River American Canyon
	Hayward Lower Alameda Fremont Upper Alameda (Contra Costa)	San Mateo	Pacifica Pescadero Half Moon Bay
Contra Costa	Marsh Creek Kellog Creek Antioch West Pittsburg Delta Lowland		Brisbane South San Francisco Millbrae-Burlingame
	Walnut Creek Diablo Alhambra		San Mateo Belmont-Atherton San Francisquito
	San Pablo Pinole Richmond	Santa Clara	Palo Alto Santa Clara San Jose Coyote-Silver (Llagas-Uvas)
Marin	Richardson Bay Corte Madera San Rafael	Solano	Fairfield Collinsville (Wooden Valley-Napa)
	Novato San Antonio		Vallejo-Benecia
	Lagunitas Tomales Point Reyes Bolinas-Stinson	Sonoma	Glen Ellen Sonoma Bayside
			Petaluma Valley

E. Ranking Surface Runoff Problems by MAC Watersheds

By performing the comparisons described in sections B-D, each county should gain some insight into the degree of present and future nonpoint pollution problems. The next step is for counties to rank these problems by water quality parameters according to MAC watersheds. This ranking will serve as a guide to the counties for identifying problem areas. The type and location of each problem pollutant can serve as an aid in choosing appropriate control measures. The ranking of problems by the counties will later serve as input for the area-wide ranking by ABAG staff.

The suggested method for ranking problem areas is according to greatest pollutant load from a specific sub-area. Although not required, the counties may also wish to include additional columns showing the actual pollutant loading and the land use in that sub-area. For example, by reviewing a MAC output, it is found that the BOD pollutant loads are greatest in sub-area C in watershed SC3. This watershed would then be ranked as the largest contributor of BOD_5 in the county. However, further analysis may reveal that a different watershed is the largest contributor of solids. The identification of land use within the watershed requires some special calculations. ABAG's consultant, Metcalf and Eddy, can supply the information necessary to complete these calculations for those counties who request it. Table 3 is provided to indicate the method of ranking.

TABLE 3

RANKING OF CONTRIBUTION OF SUB-AREAS AND LAND USES TO TOTAL POLLUTANT LOADS

	optional				optional			
Rank					SS			TN / TP
	Loading (1000 lbs.)	land use	water-shed	sub-area	land use	water shed	sub-area	same divisions for TN, TP
1	192	Com	SC3	C	Ind	SC2	C	
2	181	Ind	SC2	C				
3	159	Com	SC2	B				
4	157	RES	SC1	A				

F. Public Surveys

An excellent example of broadening the scope of the problem identification process is the questionnaire prepared by San Mateo County. Using surface runoff problems identified in Technical Memorandum No. 5, the county staff developed a questionnaire requesting information from county residents relating their knowledge of the problems and possible solutions. A copy of this is presented in Table 4.

G. Summary

The identification and ranking of surface runoff problems represents a substantial step in the control and reduction of nonpoint sources of pollution. The methods for problem identification and ranking presented in this technical memorandum are:

- comparison of point sources and nonpoint sources by concentration of pollutants
- comparison of total pollutant loads
- ranking of pollution problems by parameter and MAC sub-areas
- problem identification through public involement

It is anticipated that completion of these procedures will greatly aid in the process of control measures selection.

TABLE 4

SAN MATEO COUNTY 208 PROGRAM

Agency:
Completed by:

	Problems Related to Surface Water Runoff Quality	Existence of Problem				Location(s) of problems, if applicable	Controls used now by Agency	Possible near or long-term solutions	Comments
		No	Some	Extensive	Data				
1.	Problem in the Stormwater system								
	a. Siltation or debris in channels.								
	b. Significant Steambed erosion								
	c. Significant Infiltration & resulting strain on sanitary sewer system								
	d. Cross-connection between storm drains and sanitary sewers								
	e. Debris in catch basins								
	f. Excess aquatic or channel weeds								
	g. Other								
2.	Problems in the Water								
	a. Algae bloom								
	b. Stagnant water								
	c. "Rough fish"-fish kills, fewer fish								
	d. Grease, oil, scum								
	e. "Unnatural color."								
	f. Odor								
	g. High bacteria levels								
	h. Other								
3.	Problems on the Land								
	a. Malfunctioning septic tank leach field								
	b. Chemicals, oils discharged into drainage system								
	c. Steets, parking lot dirt and debris (steep road cuts)								
	d. Construction site erosion								
	e. Significant fertilizer pesticide application near drainage system								
	f. Highly erodable soils								
	g. Overgrazing								
	h. Poor tillage practices								
	i. High concentration of animals near drainage system								
	j. Other								

SURFACE RUNOFF MANAGEMENT PLAN

GUIDANCE FOR PREPARATION OF THE DOCUMENT DESCRIBING COUNTY SURFACE RUNOFF PLAN

TECHNICAL MEMORANDUM No. 8

JULY 27, 1977

A. Purpose

The pupose of this Technical Memorandum is to outline the content of the draft document which will be submitted to ABAG on August 31. The organization of the different sections in this outline is consistent with other EMP management plans. However, counties which have a strong preference to modify this outline or a portion of it are free to do so.

B. Format

We suggest that all documents be typed single-spaced with double spacing between paragraphs. In typing the sections and paragraphs of this document, please follow the format of all other Technical Memoranda and Progress Reports produced to date. If possible, please use letter gothic ballhead on an IBM typewriter.

The document submitted to ABAG on August 31 will be a working draft. Therefore, if needed, feel free to insert hand written corrections or additions. Also, all the accompanying graphs, tables, and maps do not need to be final.

C. Plan Outline

1. PURPOSE OF DOCUMENT

This section should contain a short description of plan objectives and the purpose that this document will serve. It should also discuss the intra-county review process, possible changes during regional integration of county plans, and the subsequent regional plan approval.

2. GENERAL DESCRIPTION OF THE PLAN

This description should be a simple and easily understandable outline of the plan. Emphasis should be on the following:

- o what is the plan
- o which problems are being dealt with
- o what are the costs
- o who will pay
- o who is doing what

The plan description should emphasize programs for immediate implementation and programs that will be done as part of the continuing planning process.

Table 1 illustrates a plan summary for a sample control measure. Counties should fill in the table for each control measure in their plan. If a county prefers, this summary table may be included as part of section 6 ("the plan") instead of in this section. A description of the information which should be provided under each column heading in the table is found in section 6 of this memorandum.

3. EXISTING AND POTENTIAL PROBLEMS AND THEIR CAUSES

The following should be included in the description of the county water quality problems and causes:

a) Nature of the problem - distinction should be made between the following three kinds of problems:

- o problems on land - such as, erosion from construction activities, debris accumulation on streets, oil and grease on parking lots, accumulation of industrial, municipal and mining wastes, erosion of agricultural land, etc.

- o Problems in streams and in other conveyance systems such as, siltation and debris in channels, turbidity, high bacteria or nutrient levels, algae blooms, presence of oil, grease and other floating material, odor and color problems, presence of toxic chemicals (heavy metals, pesticides) etc.

- o Problems in receiving waters - (San Francisco Bay, reservoirs, major streams) - such as, lowered dissolved oxygen levels fish kills, shellfish bed contamination and impairment of beneficial uses. Emphasis should be on the total pollutant loads to the receiving waters.

b) Location - a map should be prepared which shows the problem areas. Attachment A contains guidelines for preparing this map. A brief discussion of the map and the implications of the problem locations should be included.

Table 1. Plan Summary For A Sample Control Measure

Problem	Recomm. Control Measure		Description	Implementing Agency	Scheduling Actions	Legal Authority& Enforcement	Financing Mechanism	Measures to Ensure Implementatn	Remarks
	Policy	Action							
Presence of debris, litter and oil in streets and gutters.	To reduce accumulation of debris, litter and oil by encouraging their proper disposal.	Establish an anti-litter program	Media campaign, distribution of addition-al receptac-les, posting of signs	County Pub. Works; City police dept. CHP.	Begin July1, 1978 (year1) Program fully Oper. July 1,1979, continuing thru year 6.	City & Co. litter ordinances Fines for littering enforced by County & City police	Local funds		
		Establish crankcase recycling program	Work with service stations to setup recycling points;find markets for used oil; publicize recycling	County and City public works dept.	Same as above	Further ordinances may be needed. voluntary enforcement	Local funds partially offset through sale of recycled materials.		
		Set up neighborhood composting program.	Establish sites for homeowners to deposit lawn and garden clippings	County Health Dept.	Same as above	Same as above	Same as above		Possible incentive: give com-posted soil free to participant

c) Time varying characteristic - the following should be included in the problem discussion:

- o problem changes over the 25-year planning period (1975-2000), including discussion of the bar graphs from the second county progress reports.

- o seasonal problems (such as accumulation of leaf litter in the fall).

- o problems occurring during a limited time period (a three year construction project, for example).

d) Problem severity - this paragraph should provide some ranking of the problems. Also, it should include reasons for doing something about them.

4. THE DATA BASE

This section should briefly describe the available hydrologic and water quality data in the county. It should contain a map showing the location of data points and a table of labels describing the information available at these points. Attachment B outlines the recommended procedure for preparing the map and labels.

5. THE TECHNICAL APPROACH

This section is intended to briefly document the methodology used in county plan development. It can, if a county prefers, be produced as an appendix. The discussion should describe the following four major program elements and explain how the information from each element was used in the plan development process:

- o county-wide survey of problems

- o monitoring program

- o modeling program

- o development of control alternatives

Emphasis should be placed on the interrelationships between these program elements. Criteria used for evaluating the seriousness of pollutants and methods used to relate pollutants to possible sources should be discussed with specific examples. Criteria used for assessment and evaluation of control measures should also be discussed.

In addition to the description of program methodology, this section may include a documentation of the technical work. If such a documentation is prepared, it should definitely be included as an appendix. This appendix should contain a summary of the most important information presented in the county progress reports. It is suggested that the following topics be covered:

a. Surveys and Research

(1) Review of past studies

(2) Surveys of local, regional, state and federal agencies regarding water quality problems

(3) Overview of available water quality and quantity data

b. Water Quality Sampling Program (under 208)

(1) Program description - monitoring sites (refer to map in section 4), parameters sampled, watershed characteristics.

(2) Presentation of results - including graphs of concentrations versus time for each major parameter sampled.

(3) Analysis of results - what questions did the sampling program answer. Tables comparing this season's sampling results to past year's data, sewage effluent and water quality standards may be included.

c. Modeling Program

(1) MAC model

(a) Description of MAC watersheds and subwatersheds and criteria for defining them.

(b) Preparation of input data - sources of data and method for converting to model input format.

(c) Presentation of results

(d) Comparison of surface runoff to point source loads.

(e) Ranking of importance of source areas.

(2) SWMM model

(a) Description of demonstration watersheds and criteria for defining them (refer to map).

d. Development of Control Measure Alternatives

(1) Discussion of the control measures questionnaire and its effectiveness

(2) Evaluation of existing practices

(3) Formulation of control measures alternatives

6. THE PLAN

This is the main section of the document. The purpose of this section is to provide the details of the plan elements outlined in Table 1 (the plan summary). Below is a description of the column headings in this table:

Pollution Problem: Brief statement of what the problem is. Statement should be as specific as possible, referring to type of pollutants and location (for example, presence of debris, litter and oil in streets and gutters; or, soil erosion on steeply sloping rangeland) Whenever possible refer to map of problem locations (discussed in Attachment A).

Policy: The overall objective of one or a group of related control measures identified as actions.

Action: The specific control measures to be taken to implement a policy.

Description: Optional supplementary information about each action. May include a brief explanation of what the action consists of and where in the county it is to be applied.

Implementing Agency: The agency or agencies responsible for initiating and coordinating the action. In some cases there may be a need to have one lead agency coordinating the efforts of several implementing agencies (see example in Table 1).

Scheduling of Actions: The timetable for implementation. It should include the date on which an action is initiated, the date by which the action should be operational and the duration of the action.

Legal Authority and Enforcement: The constitutional provisions, statutes, or ordinances which enable the implementation and enforcement of the action. If no such enabling legislation exists, counties should specify what is required. Penalties for non-compliance with the control measure should be specified.

Financing Mechanisms: The sources or potential sources of funding the action.

Measures to Ensure Implementation: What actions will be taken by whom if the implementing agency does not carry out the control measure.

Remarks: Optional comments about any item in the table, such as incentives for encouraging participation in the action.

Table 1 is only a summary of the plan. More detailed information is required. It is recommended that the follwoing items be covered in this section.

a) Plan Map

Most control measures will not apply to entire counties. They will often pertain only to specific jurisdictions, parts of jurisdictions or sites. Mapping these areas will help to clarify the plan. Attachment C provides guidelines for preparing this plan map.

b) Plan Timetable and Sequence of Actions for Initial Implementation Period

The plan should specify a clear, step-by-step process for initiation, enforcement and monitoring the effectiveness of each control measure. It is recommended that a bar chart be prepared showing the implementation schedule for the control measures over the 6-year period. Figure 1, based on a portion of Sonoma County's initial draft plan, illustrates such a chart.

It is further recommended that the activities during the first two years be expanded to show the month-by-month schedule of activities. Much activity will take place during this initial period. In order to assure that plan implementation will proceed as scheduled, it is necessary to begin thinking now about the sequence of events which will need to occur during the first two years.

Figure 2 provides an example of how the sequence of activities might look for the control measure "control the use of certain chemicals." This sequence was based on an implementation checklist prepared by Sedway/Cooke in Report #1 - Amplification of 13 Selected Surface Runoff Measures. The sequence illustrated in Figure 2 is probably simpler than would be required for other control measures. Measures involving coordination among several cities, the county, regional and state agencies would involve many more steps (see, for example, the implementation checklist for control measure: A-6 Control Littering and Solid Waste Practices).

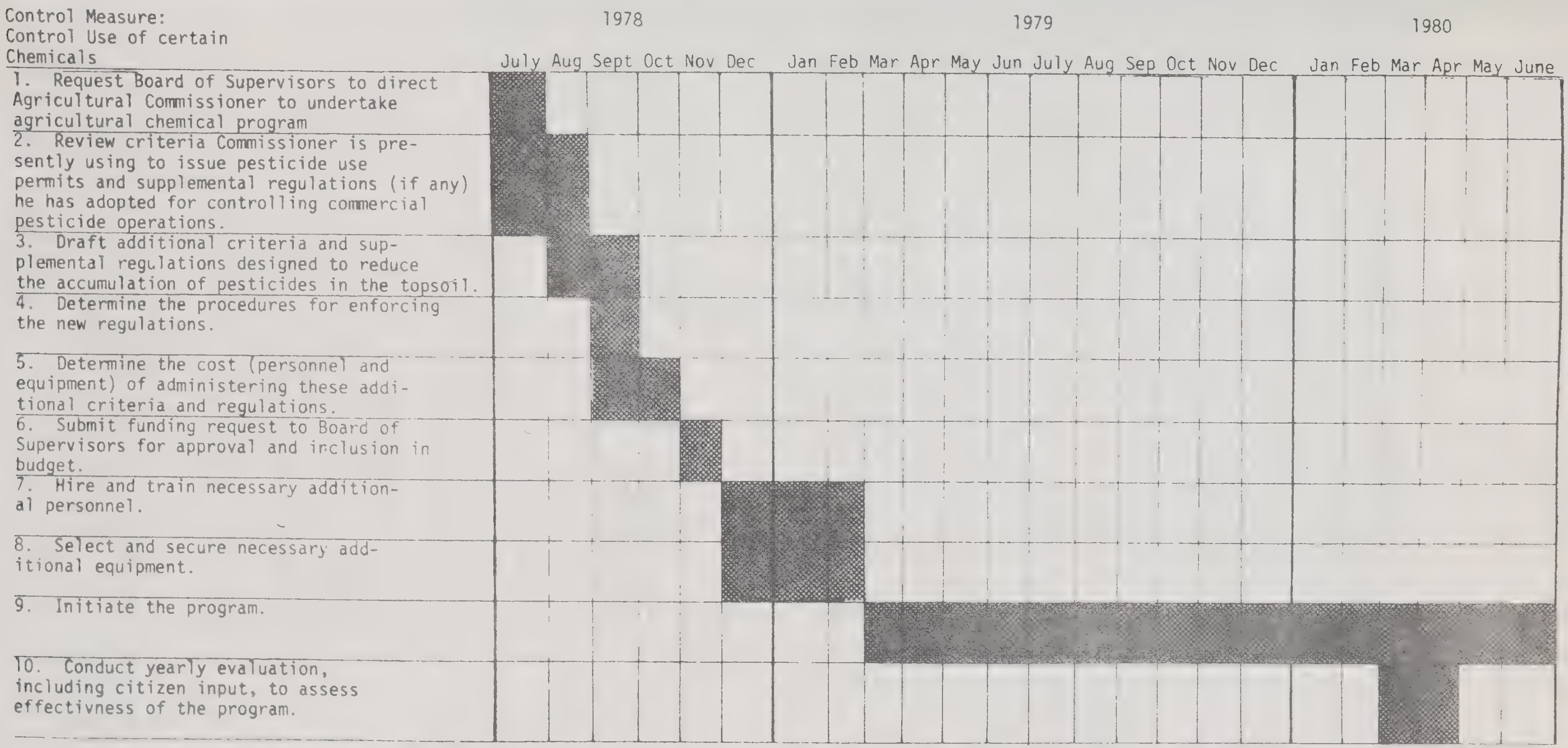
The Sedway/Cooke checklists are very useful tools for developing the detailed sequences of events for implementation of control measures. However, to adapt them for use in plan development, it is necessary to specify the participants involved in evaluating existing practices, developing program descriptions, coordinating with various agencies, hiring

Figure 1. Implementation Schedule

Control Measure	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Initiate public education program stressing good land management values						
Monitor upstream and downstream of suspected problem areas to determine pollution significance and effectiveness of control measures.						
Cities establish neighborhood compost sites and study feasibility of establishing recycling sites for crankcase oil & household chemicals.						
Adoption of county erosion control ordinance.						
County initiates street sweeping program in high density areas.						
Cities intensify their implementation activities prior to start of rainy season.						
Passage of ordinances requiring buffer strips, holding ponds, increased setbacks, litter control etc., if monitoring shows no substantial improvement in water quality.						
Development of rangeland management plans. Adoption of additional control measures by cities.						

FIGURE 2

SEQUENCE OF ACTIVITIES FOR INITIATING SAMPLE CONTROL MEASURE



personnel and purchasing equipment; and the "governing bodies" to which draft ordinances and funding requests are to be submitted. It is also necessary to specify the timing for each step in the list.

The plan timetable and sequence of actions should be both a plan and a continuing planning process. The continuing planning process is the feedback system within the plan in which information gained from preceding elements is used to further develop the plan. For example, monitoring the effectiveness of a first year control measure to determine if a new control measure is necessary in the third year is a continuing planning process.

In preparing the detailed sequence of events for implementation of a control measure, it is necessary to identify:

1. The agencies or governmental bodies involved and their existing powers and policies.

2. Funding requirements, sources of funding, procedure and timing for securing approval of funding from governing bodies (consistent with the regular budgeting process).

3. Ordinances required and procedure for drafting and approval.

4. Agreements necessary among jurisdictions, agencies and governing bodies and procedure for working out these agreements (i.e., sequence of meetings with milestones showing dates various decisions will be made).

5. Enforcement mechanism (who will enforce the measure, by what legal authority and how will measure be enforced - such as, by hiring additional inspectors to cite violators).

6. Personnel and skills needed for implementing, enforceing and monitoring the effectiveness of the control measure.

7. Equipment requirements.

8. Procedure for evaluating the effectiveness of the control measure.

Not all of the above steps will be necessary for every control measure. However, in developing a sequence of activities, it is helpful to consider each item in the checklist for applicability.

c) Assessment of Control Measures

The assessment section describes the environmental, institutional/financial, economic and social impacts of the plan. Tables 2 and 3 are example impact assessment summary tables. These tables are companions to the plan summary tables. Both tables display key information for the decision-makers.

The text of the assessment section provides the detailed impact information about the plan. The impacts of a control measure on an assessment factor (e.g. flora and fauna) are identified using the procedures in the Surface Runoff Assessment Procedures Manual. The assessment worksheets provide a ready place for impact documentation. To the extent possible, impacts should be quantified. It is also possible to show an example of the kinds of impacts that might occur based on certain assumptions (see Table 3 for the range of possible added housing costs attributed to Best Management Practices for erosion control). The EXPLANATIONS/NOTES section of the worksheet should show all assumptions used in developing such an example. A concise statement of the impact of the control measure on the assessment factor should appear there. These concise statements of impacts should facilitate writing the assessment section and the summary tables.

The assessment section of the plan should be divided into the four major headings that appear on the summary table -- Environmental Impacts, Institutional/Financial Impacts, Economic Impacts and Social Impacts. This organization reflects the categories of the Assessment Checklist. The text would present a more thorough description of the impacts summarized on the tables.

The summary assessment information on the example tables is provided as guidance. The level of detail may be greater where control measures are more specific than the examples used.

7. OTHER OPTIONS NOT INCLUDED IN THE PLAN

This section should include a table of all control measures listed for consideration in the county surface runoff contracts, covered in the Woodward-Clyde workbook or described in other sources.

Table 2. IMPACT ASSESSMENT SUMMARY

CONTROL MEASURE/ RECOMMENDATION	ENVIRONMENTAL IMPACTS	INSTITUTIONAL/FINANICAL IMPACTS	ECONOMIC IMPACTS	SOCIAL IMPACTS
Policy - Reduce Litter in Streams Action 2.2 - Monitor streams for illegal dumping, investigate source and take corrective action through to prosecution. Anti stream litter public information program.	AIR QUALITY - . minor indirect benefits of reduced odors associated with litter & debris decomposition WATER QUALITY - . maintenance of natural flow regimes major benefits during summer months when low flows are exacerbated by channel blockage . BOD levels associated with litter decomposition should be lower . prevent reductions in productivity of aquatic community - fish, consumer organisms, producers - that result from changes in the natural flow regime . prevent reductions in contact (e.g. swimming) and non-contact (e.g. sport fishing) water recreation potential PHYSICAL RESOURCES - . major benefits to the aquatic community . indirect benefits of enhanced land and water related recreation potential and use ENERGY - . no impact - clean-up handled by small scale operation AMENITIES - . direct benefits of visual impacts of debris removal from streams and stream banks - preservation of the natural state of the environment & scenic resources	FINANCIAL - Direct Cost - Public . Administrative/Regulatory Cost $37,000 annual cost (See back-up cost tables) Fiscal Effects on Local Government . minor impacts on the property tax rate- increased tax rates INSTITUTIONAL - . minor impacts on intergovernmental cooperation - other agencies may patrol streams for other purposes and contribute valuable assistance . minor impacts on legal capabilites existing ordinances, statutory responsibilities may need modified	PRODUCTION OF GOODS AND SERVICES . minor impacts of increased employment in scavenger and related businesses INCOME AND INVESTMENT - . no impacts CONSUMER EXPENDITURES - . no impacts	HOUSING SUPPLY - . no impacts PHYSICAL MOBILITY - . no impacts HEALTH AND SAFETY- . indirect, major benefits of reduced flood peaks and flood risks associated with channel obstructions . direct benefits of eliminating environments for growth of noxious species of plants and/or animals (e.g. algal blooms, rat and mosquito breeding) EQUITY - . while benefits are distributed approximately equally, costs are borne disproportionately by lower income people because the property tax is regressive URBAN PATTERNS - . no impacts

TABLE 3. IMPACT ASSESSMENT SUMMARY

CONTROL MEASURE/ RECOMMENDATION	ENVIRONMENTAL IMPACTS	INSTITUTIONAL/FINANCIAL IMPACTS	ECONOMIC IMPACTS	SOCIAL IMPACTS
Policy - Reduce erosion, sediments in water bodies, siltation Action 3.4 - Require Sediment Control Plans to Accompany Plot Plans, Building & Grading Permit Applications (Actual impacts would be site specific & require detailed assessment. Impacts noted are general impacts expected.)	AIR QUALITY - . indirect, localized, beneficial impacts of reduced amounts of dust WATER QUALITY - . reduced amounts of sediment entering water bodies from construction sites by 100 tons/sq.mi/year . reduce suspended solids available for chemical, pesticide and heavy metal binding . reduced changes (increases) in turbidity, light penetration . reduced increases in siltation of water bodies due to construction site runoff;maintain natural flow regimes especially during summer . prevent reductions in productivity of aquatic community - fish, consumer organisms, producers - associated with adverse impacts on photosynthesis, siltation etc. . prevent reductions in contact (e.g. swimming) and non-contact (e.g. sport fishing) water recreation potential PHYSICAL RESOURCES - . indirect benefits to the aquatic community, wildlife habitats . indirect recreation potential and use benefits (land and water oriented) ENERGY - . indirect, minor impacts associated with machinery and products used AMENITIES -- . indirect benefits of the visual impacts of reduced turbidity . visual benefits of preserving scenic resources, natural state of the environment	FINANCIAL - Direct Cost - Public . no additional staff required. any additional costs would be minor and offset by permit fees. Fiscal Effects on Local Government . permit fees will increase gross receipts and mitigate administrative/regulatory costs . performance bonds will mitigate any costs for clean-up, litigation etc. INSTITUTIONAL - . minor impacts on legal capabilities - existing ordinances & regulations may need modification; administrative rulemaking may be required . additional review & inspection tasks mitigated by implementation through existing administrative process. . implementing agency staff may resist additional review & inspection responsibilities or lack appropriate expertise . some jurisdictions may resist imposing further requirements on developers	Direct Cost - Private O&M Costs (Examples of Cost of Several Best Management Practices) Straw Bale Barrier $2.14/ lineal foot Siltation Berm $7.33/lineal foot Diversion Dike $3.64/lineal foot Runoff Interception Trench $6.21/lineal foot Hydromulching $989/acre The cost/acre for an Industrial or Commerical project might be $ 250-450 The cost/acre for a Subdivision $ 500-700(average) PRODUCTION OF GOODS AND SERVICES - . indirect, minor benefits of increased employment in landscaping, engineering sectors INCOME AND INVESTMENT - . indirect, minor impacts on profits for above advantaged firms . profits of firms bearing the costs of controls should not be affected assuming costs can and will be passed on to the consumer(industry dependent response) CONSUMER EXPENDITURES - . increased price of goods may occur (e.g. housing and products produced by industrial or commercial firms)	HOUSING SUPPLY - . indirect impact of reduced supply of housing may result . added site preparation and construction control costs would increase the unit costs of new housing (e.g. the average cost of a house may increase by $200 - 600 - an example design and installation cost of a BMP) . may reduce the likelihood of structural problems associated with slope instability,erosion HEALTH AND SAFETY - . indirect, major benefits of reduced flood peaks and flood risks associated with siltation . direct, major benefits of reduced erosion- 80% reduction or 100 tons per sq. mi. per year . reduced losses of productive topsoil, organic matter, nitrogen, phosphorus . reduced adverse impacts on flora EQUITY - . increased housing costs may put housing further from the reach of low and moderate income people URBAN PATTERNS - . no impacts

Below is an illustration of such a table.

Control Measure	Description	Will Measure Be Applied in the Plan?	Comments

The third column in this table should indicate with a yes, no or maybe whether the control measure will be applied in the plan. If yes, the comment column should refer to the section of the plan (table, map, etc.) where the measure is discussed. If no, the comments should explain the reasons why the control measure was rejected. Counties may, at their option, include the rejected measures in the assessment table. If maybe, the comments should discuss the conditions which would make the measure applicable in the plan. Some control measures, such as municipal trash pickup, may already be in practice, but are not considered part of the plan. The reasons why these measures were not considered part of the plan should be specified.

INSTRUCTIONS FOR PREPARING THE PROBLEM LOCATION MAP

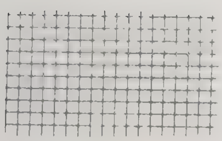
The purpose of preparing the problem location map is to illustrate areas in the counties which exhibit existing and potential water quality problems. This map will not be the final map used in the plan,but will be used as a tool for plan integration by ABAG and the counties. Therefore, the intent of this map is a draft display of information prepared by the counties (see Figure 3).

The counties should use their county portion of the regional MAC watershed map provided by ABAG. The scale of this map is 1:125,000. Additional maps are available on request. Although most of the potential problems are non-point pollution problems, many of them can be represented on a map of this size by a symbol. An obvious exception to this is a problem related to erosion, which may cover a broad region.

The symbols chosen to represent surface runoff existing/potential problems are given below. Some of these problems may occur in the same location, causing difficulty in showing these on the map. Therefore, if needed the counties are encouraged to use more than one map to show problem areas. If the counties identify problems not present on the following list, they should choose an appropriate symbol and briefly explain what problem it represents. It should be noted that both sources of surface runoff problems (i.e., erosion) and problems in receiving waters (i.e., sedimentation) are included in this map.

Existing/Potential Problems

Erosion:



Includes all major forms of water erosion; sheet, gully and streambank. Some counties may wish to treat streambank erosion as a separate problem. This may be shown by marking short lines perpendicular to the flow of the stream. Problem areas should be outlined and accented with a grid pattern. Criteria for problem areas should include areas identified by the U.S.G.S.[1] and local investigations.

Sedimentation:

Sedimentation problems are defined as deposition of significant quantities of solids in stream channels, reservoirs and flood plains. "Significance" is determined where damage occurs and/or where money is expended for dredging or other corrective measures.[2]

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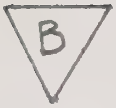
[1]Nilsen, Tor and Robert Wright. 1975."Regional Slope Stability of the San Francisco Bay Region"(3 plates). U.S.G.S. Menlo Park.

[2]ABAG will distribute shortly the results of a survey of water quality problems in Bay Area reservoirs. The survey results should include information on sedimentation in these reservoirs.

Biological Degradation:



Because of the difficulty in assessing biological problems in water, these problems have been combined into one category. Biological degradation would include, but not be limited to the following: fish kills, algae blooms, aquatic weed overgrowth, oxygen depletions and loss of desirable species.

Floatables:

To be included in this group are oil and grease, litter and debris. Water bodies and land areas in the county with obvious floatable materials present should be identified.

Bacteria:

Water with bacteria counts exceeding standards should be located.[3] Local health department surveys are helpful in this regard.

Toxic Materials:

This category encompasses heavy metals, radionuclides, pesticides and other trace organics. Problem determination should consider standards,[4] where they exist, and concentrations measured in surface waters and organisms.

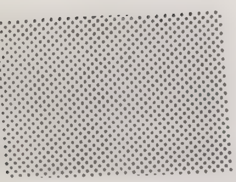
Organics:

Organics, for this purpose, include leaves, animal wastes and other materials which are measures as BOD/COD/TOC, etc. These may be evidenced by dissolved oxygen depletions in water.

Groundwater Degradation:

This should specify locations where the quality of surface runoff threatens to degrade groundwater supplies. Areas of special consideration are groundwater recharge zones downstream from urbanized regions.

Flooding:



Where modification of the hydrologic cycle has occurred to such an extent as to cause or increase local flooding. It is the experience of staff that surface runoff quality problems often occur simultaneously with surface runoff quantity problems.

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[3]See Basin Plan (also Tech. Memo. #5, Appendix)
[4]See Basin Plan (also Tech. Memo. #5, Appendix)

Septic Tank Failure:

(optional) ABAG has prepared a map of areas in the Bay area with septic tank problems.[5] For the purposes of continuity, the counties may wish to include this possible pollution problem along with those mentioned above.

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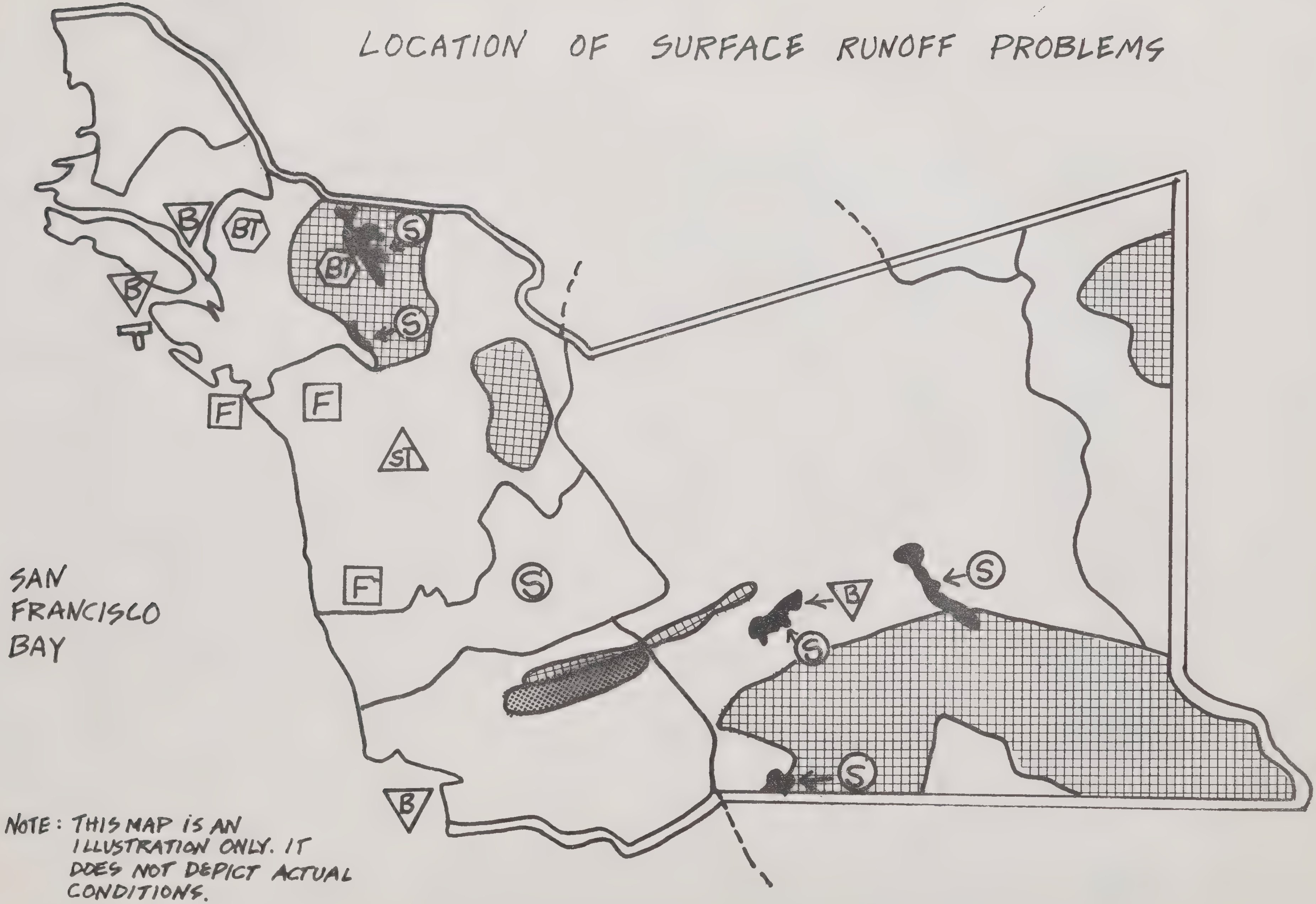
[5] ABAG, Feb. 1977, "Septic tank systems - the problem and possible Solutions". Water Quality Management Plans, Tech. Memo. No. 4.

FIGURE 3



ALAMEDA COUNTY

INSTRUCTIONS FOR PREPARATION OF DATA BASE MAPS

The purpose of this map is to include in the Surface Runoff Management Plan, a standard reference for all hydrological and water quality related data. Compilation of this information will be needed in the continuing planning process. Virtually all of this information is available on ABAG base maps (See Tech. Memo. #2). The counties are expected to transfer this information from ABAG's base maps (scale 1:24,000) to the MAC base map (scale 1:125,000). Also to be added to the MAC map should be the boundaries of the demonstration (SWMM) watersheds and the location of the monitoring sites set up as part of the 208 program.

Each of ABAG's base maps contained a symbol referring to a certain type of data and a label with more detailed information regarding the source, the quality and the length or period over which the data was collected.

Certain changes in using these symbols and labels are suggested. Each climatological and hydrological monitoring station in a county is to be represented by the appropriate symbol, station identifier and data label. The symbol and the identifier will appear on the map. The labels will be grouped together in a table.

The station symbols are suggested below:

●	- Streamflow Gauging Station
○	- Inoperative Streamflow Gauging Station
■	- Streamflow and Sediment Discharge Gauging Station
□	-Inoperative Discharge Gauging Station
▲	- Water Quality monitoring
◆	- Rainfall Gauging Station-continuous
◇	- Rainfall Gauging Station-other
✱	- Evaporation Gauging Station
➡	- Wasteload Outflow Location

Each station symbol will be identified by the following alphanumeric code:

(1) a letter

S - denoting a streamflow gauging station

Q - Denoting a sediment and water quality gauging station

R - denoting a rainfall gauging station

E - denoting an evaporation gauging station

(2) a digit denoting county identification (digits 1-9 correspond to Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Solano, Sonoma)

(3) a dash (-)

(4) two digits describing sign control identification within a county of all gauging stations of a given type (S,Q,R, or E)

Each alphanumeric code will be keyed to a descriptive label as shown below. Labels should be presented in numerical order and grouped by symbol type (e.g., all streamflow gauging station labels should appear in sequence). ABAG will prepare and distribute forms for typing these labels.

A reduced version of the data labels is displayed below. Please note the appropriate code and symbol for proper label identification.

◆ R6-01	
STATION NAME NUMBER, AND ELEVATION	Curtner Ranch D10-2232-10 650'
PERIOD OF RECORD	19[illegible]4 - present
MISSING YEARS	-
SOURCE OF DATA	Santa Clara County Water Conservation District

■ S1-01	
Agency	USGS No. 9000
Monitoring Period	1891 - (discharge), 1952-73 (quality)
Location	Alameda Creek near Niles
Nature	continuous for sed. conc., quarterly for particle size
Type of Data	daily and peak discharge, sediment, dissolved solids, chloride, N, common ions, hardness, minor elements, temp., sp. cond., pH

* E7-01	
STATION NAME AND ELEVATION	Joi[illegible] Island 10'
PERIOD OF RECORD	195[illegible] - 1959
TYPE OF PAN	Class A
SOURCE OF DATA	National Weather Service

MAPPING THE PROPOSED MITIGATION MEASURES

Preparation of this map will be perhaps more difficult and at the same time also more important than the data base and problem area maps. The goal of this step is to prepare a map which demonstrates where each control measure will be applied.

Initially, many control measures appear to apply county-wide. However, further inspection may show that actual implementation of the control measure would apply to only a small portion of the county. For example, a mitigation measure specifying control of erosion would probably only require implementation in sensitive areas such as those bordering streams or on steep slopes. Mapping of mitigation measures will therefore demand that their respective implementation processes be clearly defined. It is envisioned that this mapping process will serve as a rigorous revision of the proposed mitigation measures.

Mapping the surface runoff control measures can be facilitated by first identifying these areas on a convenient single purpose map. As an example, a control measure designed to control erosion on steep slopes could first be outlined on a topographic map. Another technique to assist in identifying areas where the control measure applies is to first delete those areas where the control measure cannot be applied. For example, a mitigation measure to establish road sweeping in unincorporated areas would not apply to municipalities nor open space areas.

In mapping the areas where the different control measures apply, the following mapping units can be used.

AREAS WHERE CONTROL MEASURE APPLIES	MAPPING UNIT
Streams Lakes Reservoirs Marshes	Water Bodies
Soil Classifications (SCS)	Soils
Geological Rock Types (USGS)	Geology
Forest Grassland Riparian	Vegetation
Existing Urban Unincorporated Urban Rural - Residential Rural - Cropland Rural - Rangeland Rural - Natural Rural - Public Use	Land Use

Low Density Medium Density High Density	Population Density
Federal & State Hwys. County Roads City Roads Private Roads Airports Railroads	Transportation System
Municipalities Resource Conservation District Water Conservation District Sewer District School District Fire District Mosquito Abatement District	Jurisdictions

The mapping of the proposed mitigation measures should be done on the 1:125,000, MAC watershed map supplied by ABAG. Should the map become difficult to interpret because of overcrowding, additional maps may be used. In extreme cases if some control measures are found to be impossible to map, they should be listed on a separate sheet. Another option open to the counties is to separate those control measures which would be implemented in the early phase of the plan (Year 1 and Year 2), and those which would be applied in the continuing planning process. It can be done by either using the different maps or one map with proper symbols, colors/ or legend.

SR/Tech Memo 9/August, 1977
J. Eilers/F. Wolin/ Y. Litwin

Surface Runoff Management Plan

WATER QUALITY PROBLEMS IN LOCAL LAKES AND RESERVOIRS

Technical Memorandum No. 9
August 24, 1977

A. INTRODUCTION

This technical memorandum presents the findings of a survey of surface runoff related problems[1] in local lakes and reservoirs. The survey singles out local lakes and reservoirs for the purpose of demonstrating the extent of:

1. nonpoint pollution problems caused by surface runoff, and

2. the resulting costs of mitigation measures to control these problems.

The overall objective is to provide a regional view of problems within lakes and reservoirs under the jurisdiction of Bay Area water supply, flood control and recreation districts. In total, 68 lakes were investigated. Excluded were water supply distribution reservoirs with no drainage area and many small, privately owned lakes. This survey was limited to the ABAG 208 water quality study boundary (see Figure 1). The results are presented in the Appendix.

Sixty percent of the surveyed lakes serve as water supply reservoirs. Traditionally, all problems affecting such reservoirs were viewed as water supply problems. However, such artificial distinction is no longer valid. It is becoming increasingly apparent that the activities on land and the resulting nonpoint pollution are reflected in the quality of all the receiving waters, such as streams, lakes, marshes and the Bay. The surface runoff related problems in the surveyed reservoirs must, therefore, be viewed as part of the regional surface runoff problem. The only difference is in the fact

[1]Problems, as used in this memorandum, are defined as impairment of the desired and/or designated beneficial uses.

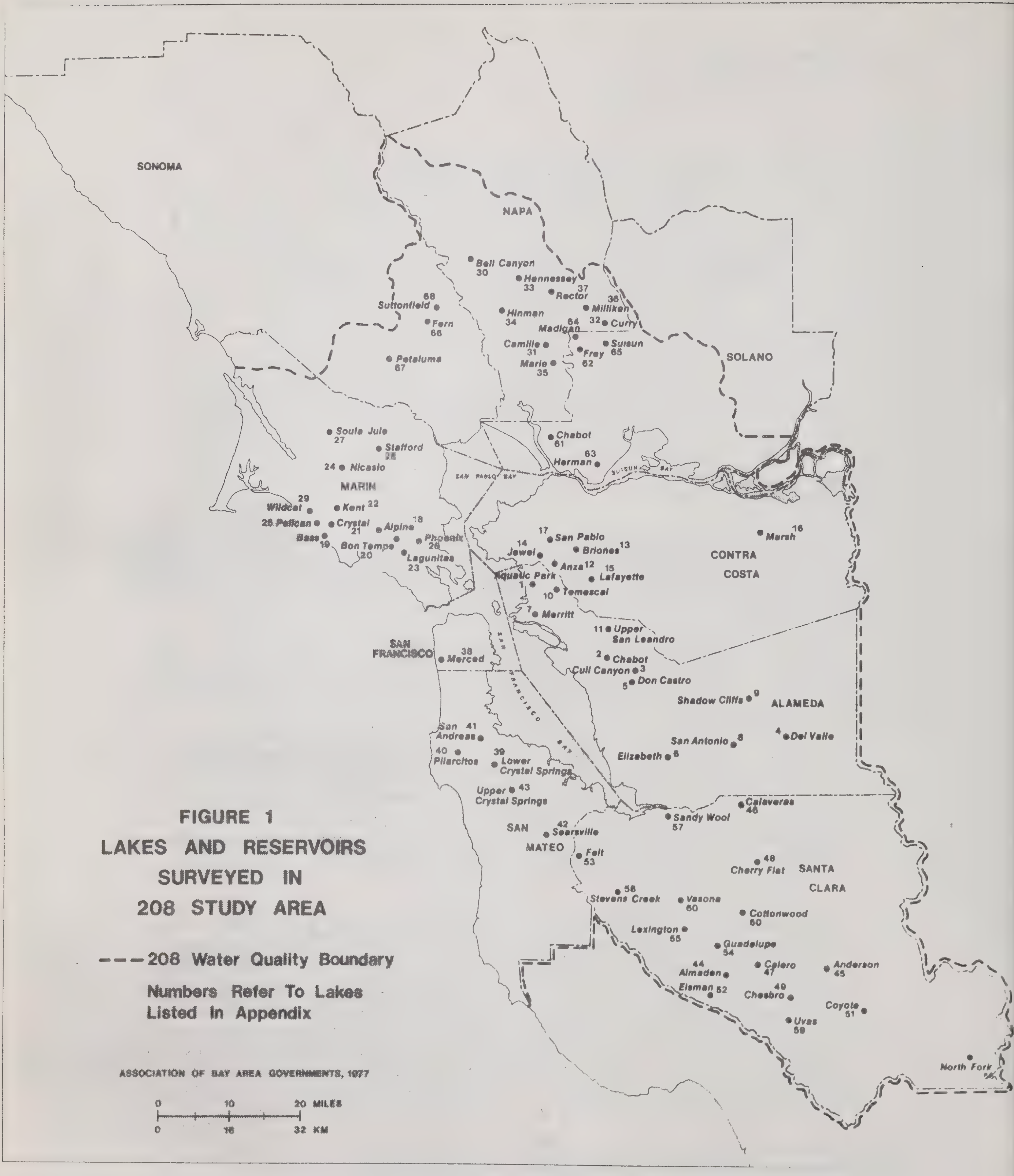


FIGURE 1
LAKES AND RESERVOIRS SURVEYED IN 208 STUDY AREA

- - - 208 Water Quality Boundary

Numbers Refer To Lakes Listed In Appendix

that due to the special sensitivity to problems in water supply reservoirs, we possess a better knowledge of the relationship between nonpoint pollution problems and the resulting costs of mitigation measures.

B. SUMMARY AND CONCLUSIONS

Many local reservoirs are experiencing problems which impair former beneficial uses and threaten existing uses. In some reservoirs the problems are severe requiring hundreds of thousands of dollars to correct. Most reservoirs in the region show some problems, but to a lesser degree. It must be emphasized that the total number of reservoirs with identified problems is likely to be greater than that revealed in a telephone survey. The most significant problems that were identified through this survey are as follows:

Siltation	This is clearly the most serious problem in local reservoirs. Twenty-eight percent of the reservoirs are identified as having known sedimentation problems. The actual number affected is probably much greater. Most of the $5 million currently being spent on lake improvement is related to this problem.
Oxygen Depletion	Thirty-eight percent of Bay Area lakes surveyed by the USGS in 1974 experienced oxygen depletion. It is not known to what extent this problem results from nonpoint pollution.
Algae Blooms	High populations of algae and aquatic weeds are a concern in almost all lakes surveyed. Where they are not identified as a problem, mitigation measures (such as copper sulfate) are regularily applied for prevention. In some cases soils and parent geologic material contribute significant amounts of nutrients to these lakes. However, the problem is virtually always exacerbated or directly results from man's activities in the watershed.
Fish Kills	Twenty documented fish kills have occurred in local lakes and reservoirs since 1963. As many as 75% of these fish kills may be the direct or indirect result of nonpoint source pollution.

The activities which contribute to these problems result in a significant loss of beneficial uses. The most serious economic impact from siltation is the loss of active reservoir storage.

Various methods for controlling problems in and around local reservoirs are being implemented. Basically two approaches are being used:

Engineering Control Measures	These consist of structures such as sedimentation basins and activities including dredging, aeration, aquatic weed harvesting and herbicide application.
Land Use Control Measures	These involve changes in land use such as buffer strips, zoning regulations and creation of watershed preserves.

The total expenditures attempting to correct these problems currently exceed $5 million.

Based on this survey, we recommend the following actions:

(1) Further analysis of the degree of problems in local reservoirs should continue. This analysis should include reservoir sediment surveys, identification of pollutant sources and cost-effectiveness information for problem control.

(2) The analyzed problems should be ranked and incorporated in the local Surface Runoff Management Plans. Possible funding for dealing with these problems should be sought under the Clean Lakes Act or its future extension. To date, three local lakes (Temescal, Lafayette and Stafford) are participating in this program to improve the water quality. The total level of Federal support is $570,000.

C. THE NATURE OF POLLUTION PROBLEMS

Few natural lakes are found in the San Francisco Bay Area. Of the 68 lakes surveyed, only five are natural. A major source of water to Bay Area reservoirs is imported water (e.g., Hetch-Hetchy Aqueduct), accounting for slightly more than one-half of the local water use (J. B. Gilbert and Associates, 1977). Groundwater, direct precipitation and surface runoff provide the remaining portion. Assuming a gross runoff coefficient[2] of 0.34, surface runoff from surrounding watersheds accounts for approximately 17% of the regional total water content in these reservoirs. This value may vary from 5 to 50% depending on the reservoir and the rainfall year.

Most of the lakes and reservoirs are located near steep hillsides. They are, therefore, susceptible to sedimentation. The process is further accelerated by man's activities which expose the soil to erosion. Sediment yields from urbanized or developing areas are from 2 to 500 times greater than non-urbanized areas (Leopold, 1968). In addition to trapping water for use during summertime, reservoirs with a large storage capacity also trap 95 to 99% of the sediment that flows into the reservoir (Leopold, et al, 1968). This trapping efficiency decreases as reservoir capacity decreases.

[2]Runoff coefficient is the value which reflects the imperviousness of the land surface. A high coefficient is indicative of a surface which will result in a high percentage of the water running off the land.

Erosion is not only caused by the exposure of soil, but also results from the increased volume and peak flows from these areas. In other words, when land use patterns are changed and watershed runoff characteristics are altered there is a significant change in the timing, volume and peak flow of a given storm (see Figure 2). These factors combine to increase erosion from land surface. In addition, they also increase erosion in stream channels. Streambank and streambed erosion may account for over 50% of the total export of sediment from the watershed (Anderson, 1975).

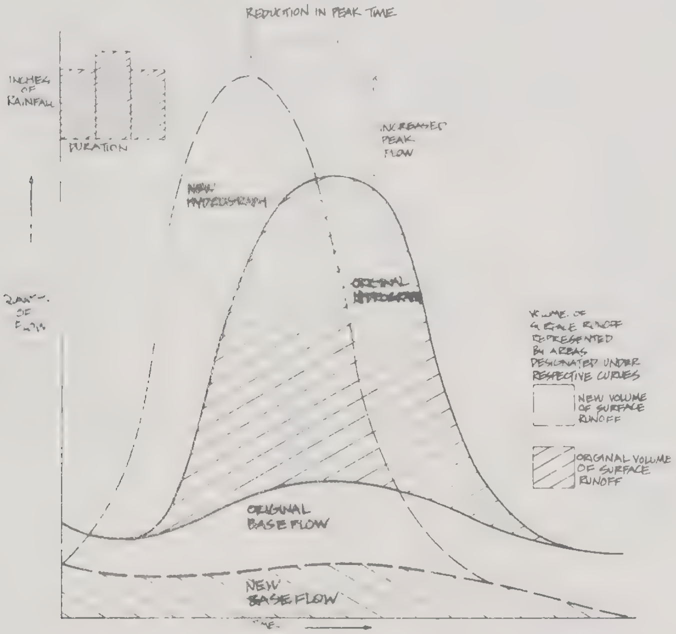


FIGURE 2:
CHANGE IN STREAM HYDROGRAPH CAUSED BY DISTURBANCE OF LAND SURFACE

Sedimentation contributes to several other problems in lakes and reservoirs. The incoming sediment usually transports large amounts of nutrients. In lakes where these nutrients (especially phosphorus) are limiting for plant growth, large population of algae and aquatic weeds may develop. The sediment also contributes to the problem of rooted aquatic weeds by providing additional shallow areas for suitable habitation.

In turn, the additional plant growth contributes to dissolved oxygen problems. The plants, upon dying, sink to the lake bottom and are decomposed by various bacteria. Decaying plant and animal life, along with organic matter brought to the lake by surface runoff, uses dissolved oxygen. If the decay of organic matter becomes too great, all of the dissolved oxygen will be depleted from the bottom of the lake. Low concentrations of dissolved oxygen in the water increases the solubility of several substances (e.g., iron, manganese, phosphorus). This not only results in increased nutrient availability, but also

contribute to poor tasting water. For trout and other organisms, cold, well oxygenated water is essential for life. Therefore, low dissolved oxygen may lead to fish kills. Fish deaths may also result from actions such as application of herbicides, industrial chemicals or unknown sources. These reservoir problems and their related processes are presented in Figure 3.

D. ASSESSMENT OF POLLUTION CAUSES

1. Sedimentation

The most serious threat to local reservoirs is accelerated sedimentation resulting in reduced capacity. Where the watershed has been maintained in the natural state, sedimentation is not a major concern. In cases where the watershed is not owned by the reservoir operator, activities on the land may cause substantial sedimentation. Table 1 presents information on increased erosion from various land uses.

TABLE 1

Surface Erosion Resulting From Land Disturbance

Initial status	disturbance	Magnitude of impact by the specific disturbance a/
Forestland	Planting row crops	100-1,000
Grassland	Planting row crops	20-100
Forestland	Building logging roads	220
Forestland	Woodcutting and skidding	1.6
Forestland	Fire	7-1,500
Forestland	Mining	1,000
Row crop	Construction	10
Pastureland	Construction	200
Forestland	Construction	2,000

a/ Relative magnitude of surface erosion from disturbed surface, assuming "1" for the initial status. The first row of the table, for example, indicates that transforming a forestland into row crops will increase surface erosion 100 to 1,000 times. (EPA, 1976)

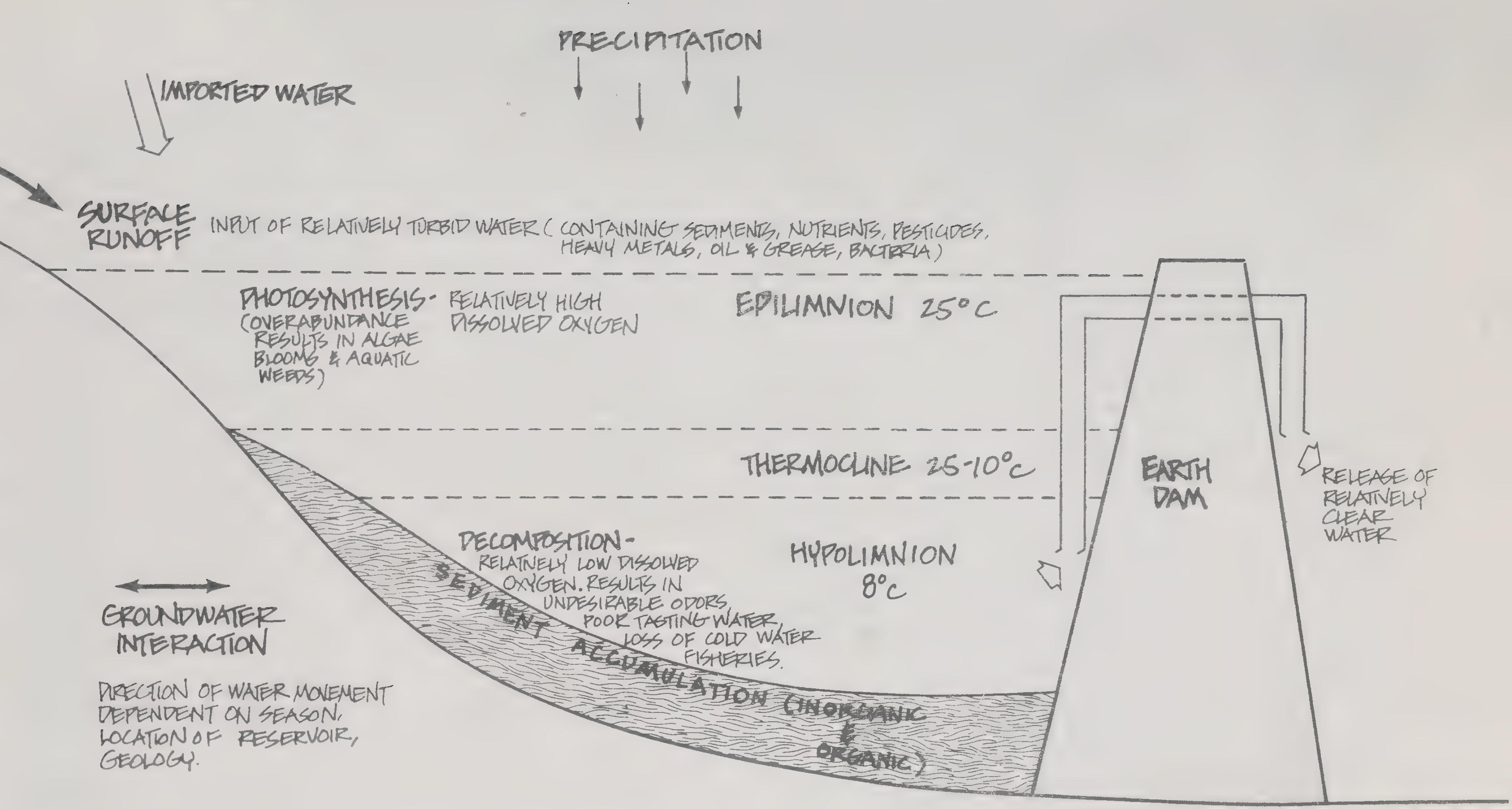


FIGURE 3:
PRESENTATION OF 'TYPICAL' RESERVOIR IN THE BAY AREA SHOWING SUMMER STRATIFICATION OF WATER LAYERS

Twenty-eight percent of the lakes surveyed identified sedimentation as a problem. Because reservoir sediment surveys are not regularly performed, it is likely that the number of lakes experiencing significant sedimentation is actually greater. The sources of erosion identified by some of the reservoir managers include construction, grazing, recreation and fires.

- Construction

  The magnitude of sediment yields from construction sites is well documented (Leopold, 1968., Thronson, 1976). For very small areas, the volume of sediment from construction areas (both dwellings and roadways) may exceed 20,000 to 40,000 times the amount from farms and woodlands in an equivalent of time (Wolman and Shick, 1967). In larger drainage areas, construction may increase sediment yield from 10 to 2,000 times over previous levels (EPA, 1976). In an analysis of 48 Northern California reservoirs, 34 variables were studied for their effect on reservoir deposition. Of these many variables, secondary roads located near streams draining to the reservoir were the single greatest contribution of sediment (Anderson, 1976).

  A local example of construction as a source of sediment to reservoirs is provided by East Bay Municipal Utility District (EBMUD). EBMUD, owner and operator of San Pablo Reservoir has determined that residential construction in the upper portion of the watershed is the major source sediment to the reservoir. Largely, as a result of the construction, an average of 170,000 cubic yards of sediment per year has entered the reservoir during the past decade (Hartman, 1977). Should it be deemed necessary, the cost of removing the sediment from the lake would be nearly $12 million (@ $7 cubic yard). Another example where specific knowledge is available is in the Colma Creek Watershed (San Mateo County). During a peak construction period in this watershed a detailed study was performed by the U.S. Geological Survey. It was found that 72% of the sediment transported from the basin was derived from construction areas representing only 14% of the basin area (Knott, 1973).

- Grazing

  In many instances grazing is a major contributor to reservoir sedimentation. Where the animal density is too great for the area of land grazed, vegetative cover is depleted, exposing soil to erosive forces. Lusby (1970, 1971) has measured 34-45% increases in sediment yields from grazed watersheds compared to natural controls. Data from the Bay Area indicates that on a long-term basis sediment yield from agricultural sources may exceed yield from construction sites (Perkins, 1976). Because 50% of the local reservoir watersheds are grazed, erosion from grazing could be substantial. Grazing has been found to be especially damaging where the animals have direct access to a stream draining to the lake because of removal of bank vegetation and destruction of streambank integrity. Horses, even in relatively small numbers, are believed to cause severe localized erosion and runoff problems (Olsen, 1977).

- Recreation

  Recreation was also identified as a problem in some watersheds contributing to sedimentation. Particularly destructive to soils and vegetation are horses and off-road vehicles, both motorcycles and 4-wheel drive vehicles. The City of Napa, believing that off-road motorcycle use was not compatible with reservoir operation, successfully opposed the creation of a motorcycle use area within the Lake Hennessey watershed. Even where the watershed is owned by the reservoir operator, control of these forms of recreation is not always possible because of manpower requirements for patrolling the property, as pointed out by the City of Vallejo. While precise data on the amount of sedimentation resulting from recreation is absent, an indication of its potential impact is demonstrated by the large number of reservoir watersheds which prohibit trespassing.

- Fires

  Grass and woodland fires create a high potential for severe erosion by destroying vegetative cover. Reservoir deposition can result not only from sheet erosion, but also from dramatic mud flows caused by hillside slumping. An average of 6705 acres are burned each year within the ABAG 208 planning area (Jackman, 1976). However, the local acreage burned to date already exceeds this figure. Unless these areas are reseeded or otherwise stabilized, the damage to both reservoirs and watersheds can be severe.

2. Algae Blooms; Aquatic Weeds

Almost all reservoirs in the area are effected to some degree by problems resulting from populations of aquatic plants. The aquatic weeds and algae interfere with recreation in the reservoirs while contributing to oxygen depletion problems.

In decaying, the plants create odor and taste problems in water supply reservoirs. Currently, several techniques for assessing the extent of the problem in lakes are being investigated, including aerial photography. Long-range control requires that nutrient supply to these plants be impeded. The two main sources of the limiting nutrients are surface runoff and internal recycling.

3. Oxygen Depletion

Dissolved oxygen depletion was sited as occurring in 38% of the 21 Bay Area lakes surveyed by the U.S. Geological Survey (Britton et al, 1974). The lakes in this previous survey consisted primarily of the larger reservoirs in the region. It is likely that the percentage of total lakes in the region experiencing low dissolved oxygen in the lake bottom is greater.

4. Fish Kills

Of the 20 reported fish kills in Bay Area reservoirs during the last 14 years, 15 were caused by nonpoint pollution-related or unknown

causes. Three fish kills were caused by over application of copper sulfate by reservoir operators. Fish kill information is summarized in Table 2. While fish kills are dramatic, observable events, fish represent a small portion of the animal life in a lake. Most aquatic animals are small, relatively non-mobile creatures which would even be more susceptible to environmental stress. Because of their size, they are often overlooked in biological surveys. A more complete assessment of lake pollution should include a survey of both microscopic and macroscopic organisms.

D. THE EXISTING CONTROL MEASURES

Where problems in local lakes have been recognized, a variety of techniques are employed to provide control. The controls and solutions are classified under engineering controls and land management techniques.

1. Engineering Control Measures

Engineering control measures are defined as mechanical, chemical or structural methods for controlling the problem. The most common engineering methods used locally are dredging, sedimentation basins, aeration, plant harvesting and application of chemicals.

- Dredging is either planned or currently under way in at least six Bay Area reservoirs. Dredging is a costly method of lake restoration and is usually only considered where sedimentation has severely affected the lake. Lake Temescal which has seen a 39% reduction in volume during the last 10 years is one such example (Alameda CFC & WCD, 1977) of restoring a lake through dredging. It must be emphasized that all of the reservoirs being dredged have some land use other than natural within the watershed.

- Sedimentation basins are another method of controlling sedimentation by intercepting the material before it reaches the lake. Jewel Lake in Contra Costa County is one of three local lakes known to use this technique. To maintain their effectiveness, the basins must be adequately sized and cleaned periodically. The basins may also serve as mosquito breeding sites if not properly maintained.

- Aeration of the entire lake is being tested as a control measure in the three local reservoirs. Lakes Temescal and Lafayette are two reservoirs which will aerate as part of their lake restoration efforts. Aeration, in addition to adding oxygen to the water, is also used to destratify the density gradients. It is hoped that this will reduce internal nutrient recycling while preventing oxygen depletion.

- Copper sulfate and other herbicides are used in practically all local reservoirs. Applications are usually made in the spring and summer when the potential for aquatic plant growth is greatest. It is uncertain what effect copper sulfate has on animal life in the lakes. There appears to be a trend away from the indiscriminate use of chemicals to control algae by some operators.

TABLE 2

FISH KILLS IN LOCAL LAKES[4]

Date	Reservoir	Species & # of Fish	Suspected Cause
6-8-74	Merritt	1 Striped Bass	-
7-6-64	Merritt	2 Shad	-
5-20-65	Cherry Flat	50 Black Bass 50 Bluegill	unknown
5-19-66	Temescal	500 ?	unknown
5-26-66	Aquatic Park	200 ?	ind. chemical
3-31-67	Nicasio	486 Bluegill	unknown
6-12-69	Chabot	12 Trout	spray paint
7-22-69	Lafayette	1000 Bluegill	copper sulfate
9-9-69	Aquatic Park	467 Striped Bass 1,000 Smelt 10,000 Scalpin 1,000 Needlefish 1,000 Stickleback	low D.O. algae bloom
4-18-70	Lafayette	200 Crappie	copper sulfate
7-27-70	Phoenix	100 Trout	hot weather
11-13-70	Bon Tempe	7 Trout 3,000 Stickleback, Shiners	copper sulfate
5-6-71	Merritt	5,000 Shrimp 1,000 Perch 100 Gobie 75 Bullhead	unknown
7-12-71	Briones	3,000 Bluegill 2 Catfish	unknown
6-3-72	Briones	1,000 Bluegill	possible spawning mortality or disease
9-8-72	Merritt	3,000 Shiner Perch	unknown
6-28-72	Hennessey	5 Hitch 25 Roach 1,000 Stickleback 3 Sculpin	low D.O.
5-3-74	Hennessey	13 Black Crappie 1 Brown Bullhead	spawning stress
4-26-76	Aquatic Park	1,000 Stickleback	ind. chemicals
8-13-76	Merced	150 Sculpin	algae bloom

[4]From Rugg, 1977

It has been found that many species of algae will experience a rapid increase in population at certain times of the year then decline within a few days without application of herbicides.

- Mechanical harvesting is a relatively new method for control of aquatic weeds. Harvesting the plants serves to remove nutrients from the lakes and provides a mulch for gardens while also improving the lake for recreation. Harvesting is currently being done in at least two local lakes--Lake Merritt and Aquatic Park.

While the above techniques often provide a temporary relief of the symptoms, they do little to control a major source of the problem--land use.

2. Land Management Techniques

Land management techniques for maintaining reservoir quality include land purchase to create buffer zones, grazing density requirements and watershed protection agreements. From the reservoir operator's position, the ideal management arrangement is to maintain the land in its natural condition. Usually this can be accomplished only when the watershed is wholy owned by the water district. Problems within these natural-watershed reservoirs are usually minor. An alternative to watershed ownership is control of the land surrounding the lake. Currently, several water districts are purchasing buffer areas, to prevent urban encroachment and to provide a surface runoff filtering zone.

Watershed lands are frequently leased for grazing purposes. EBMUD and the San Francisco Water District are examples of reservoir operators that lease their lands for grazing. Unless properly controlled, grazing can lead to serious depletion of ground cover, resulting in erosion. The above utility districts attempt to avert this problem, while continuing to allow grazing, by specifying the animal density permissible on the land.[3]

An innovative method for protecting the watersheds not owned by the reservoir operator is being used by the Marin Municipal Water District (MMWD). Under what are called Watershed Protection Agreements, land use activities which are potentially harmful to the reservoir must be approved by the MMWD. As an example, before construction of a subdivision within Nacasio watershed is permitted, the builder must provide MMWD with a plan to insure that surface runoff from the development will be controlled. MMWD reports that the results have been quite successful (Weg, 1977).

E. EXPENDITURES ON EXISTING CONTROL MEASURES

The total costs resulting from pollution of local lakes are difficult to assess. The indirect costs resulting from sedimentation

[3]Because of the drought and resulting decrease in grass production, some agencies are prohibiting grazing until adequate ground cover is reestablished.

alone include loss of recreation benefits, and other intangibles such as a decline in fisheries. Also, the cost of operation and maintenance are known to increase with declining water quality (e.g., chlorine, filtration). An additional major consequence is loss of water storage capacity and reduction in flood protection from sedimentation.

Expenditures for controlling and preventing problems in reservoirs are more easily determined. Contacts with local agencies indicated that over $5 million is currently being spent to control the problems in the lakes. The majority of these expenditures are for lake dredging and land purchases to create buffer zones. A recent investigation by the Army Corp of Engineers revealed that costs associated with reservoir dredging are 2.5 to 5 times greater than the cost for constructing a new dam at the same site (Andreas, 1977). However, because most of the favorable dam sites have already been utilized, additional dam construction does not appear to be a viable alternative.

While some reservoir operators are to be commended for their efforts to control sedimentation, there is no indication that the overall problem is decreasing. On the contrary in the lakes studied by Anderson (1976) it was shown that the rate of sedimentation was increasing at approximately one percent per year. Given the present information on the amount of construction, grazing and other activities in watersheds, it is likely that the costs resulting from reservoir sedimentation will not decrease in the foreseeable future.

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APPENDIX

SURVEY OF LOCAL LAKES AND RESERVOIRS

The survey of local lakes is presented in the following pages. The information regarding lake characteristics was taken primarily from the California Department of Water Resources (1976). Watershed information was obtained largely by personal communication with the reservoir operators. Other sources of information included the County Surface Runoff Progress Reports (1977), the ABAG Physical Resources Study (1971) and the Britton (1974) An explanation of the individual columns is provided on the following page.

Explanation of Headings In Appendix

County	- county in which reservoirs are located
Map Identification	- refers to number om Figure 1.
Name	- name of lake (where different than name of dam)
Owner	- party responsible for lake
Beneficial Uses	- as defined by Regional Board; wildlife and and fishing have beem omitted because of their use in almost all lakes.
Age	- completion date of dam
Storage Capacity	- maximum holding potential of lake (these values may not reflect existing conditions because of sedimentation)
Surface Area	- area of lake surface at maximum capacity
Drainage Area	- area in watershed not including lake area
Stream	- stream draining to reservoir
Landuse in Watershed	- predominant activities in watershed
Problems Identified	- those conditions in reservoir which are considered problems to some degree by reservoir operator
Mitigation Measures	- actions being taken to correct problems.
©	- the reader should refer to the comment column for a more complete explanation

COUNTY	LAKE IDENTIFICATION				LAKE CHARACTERISTICS						LAKE AND WATERSHED MANAGEMENT				COMMENTS
	Map ID#	RESERVOIR	OWNER	EXISTING BENEFICIAL USES	AGE (yrs)	STORAGE CAPACITY (acre ft)	SURFACE AREA (acres)	AVERAGE DEPTH (feet)	DRAINAGE AREA (acres)	STREAM	LAND USE IN WATERSHED	PROBLEMS IDENTIFIED IN RESERVOIR	MITIGATION MEASURES	COSTS ($)	
ALAMEDA	1	Aquatic Park	City of Berkeley	Recreation	38	Water Elevation Adjusted By City Of Berkeley			640	--	Recreation Industrial	Algae, Aquatic Weeds, Low Dissolved Oxygen	Plant harvester, dredging, interceptor system for drainage area	$20,000 (purchase harvester only)	Salt Water Lake
	2	Chabot	East Bay MUD	Municipal, Recreation, Agriculture	85	12600	315	40	27520	San Leandro Creek	Recreation Grazing	None	--	--	East Bay Regional Parks Controls the Watershed
	3	Cull Canyon	Alameda Co. Flood Control	Recreation	14	295	19	16	4032	Surface Runoff	Grazing Residential Construction	Sedimentation	Dredging (290,000 cu yds.)	$873,000	Paid by Alameda County
	4	Del Valle	Dept. Water Resources	Municipal, Ground Water Recharge, Recreation, Fld. Control	9	77100	1060	73	95360	Arroyo Valle Creek	Recreation	None	--	--	Administered by Regional Park District
	5	Don Castro	Alameda County Flood Control	Recreation	14	391	23	17	12544	Surface Runoff	Recreation Natural	Sedimentation	Dredging	Est. @ $3/cu.yd. $600,000	Planned removal of 200,000 cubic yards
	6	Elizabeth	""	Flood Control, Irrg. Recreation	10	450	68	7-8	N/A	Surface Runoff	Urban, Recreation	Bank Stability Sedimentation	Rip rap Silt Pond	N/A	Very heavy Recreational use
	7	Merritt	City of Oakland	Recreation	115	960	160	6-8 ft	6400	Estuary and Watershed	Urban	Sedimentation Nutrients Oxygen levels Bacteria	Plant Harvesting Machine Study on Problems w/Lake	$110/hr rental $25,000	Estuarian Lake (saltwater)
	8	San Antonio	S.F. Water District	Municipal	[illegible]	50500	826	61	25600	San Antonio Creek	Grazing Natural	Algae	Copper Sulfate	Unavailable	--
	9	Shadow Cliffs	East Bay Regional Park	Recreation	[illegible]	2975	85	35	100	Surface Runoff	Recreation	Aquatic Weeds, Snails	Copper Sulfate, Buffer Zone Purchase	$250/yr (material) $138,842	--
	10	Temescal		Recreation	[illegible]	485	15	32	[illegible]	Surface Runoff	Recreation Natural Highway	Sedimentation Oxygen Depletion, Bacteria	Dredging Sedimentation Basins	$600,000	Part of EPA Clean Program $488,972. $91,000 from CALTRANS
	11	Upper San Leandro	East Bay MUD	Municipal Recreation	[illegible]	41500	[illegible]	58	19840	San Leandro Creek	Natural	Concern over Bacteria, Sedimentation	Purchase Horse Stables	Unavailable	Ave. rate of sedimentation 150,000 cu yd/yr

COUNTY	LAKE IDENTIFICATION				LAKE CHARACTERISTICS						LAKE AND WATERSHED MANAGEMENT				COMMENTS
	Map ID#	RESERVOIR	OWNER	EXISTING BENEFICIAL USES	AGE (yrs)	STORAGE CAPACITY (acre ft)	SURFACE AREA (acres)	AVERAGE DEPTH (feet)	DRAINAGE AREA (acres)	STREAM	LAND USE IN WATERSHED	PROBLEMS IDENTIFIED IN RESERVOIR	MITIGATION MEASURES	COSTS ($)	
CONTRA COSTA	12	Anza	East Bay Regional Parks	Recreation	45	280	8	35	1024	Wildcat Creek	Recreation, Low Density Residential	Sedimentation, Algae	Copper Sulfate	$300/yr (Material only)	Tilden Regional Park
	13	Briones	East Bay Municipal Water District	Recreation Municipal	13	67500	725	83	5504	Bear Creek	Recreation, Grazing	None	Grazing, Density Control	--	--
	14	Jewel	East Bay Regional Parks	Recreation Wildlife	42	4.5	.5	8	2000	Wildcat Creek	Recreation, Residential	Algae, Aquatic, Weeds, Sedimentation	Sedimentation Basin, Dredging, Diversions	$1800/yr. (Labor only)	Tilden Regional Park Nature Study Area
	15	Lafayette	East Bay MUD	Recreation Municipal	48	3500	126	34	896	Lafayette Creek	Recreation Grazing	Low Dissolved Oxygen	Aeration, Grazing Density Control	$74,000	Part of Clean Lakes Program Sponsored by EPA
	16	Marsh	Contra Costa County Flood Control	Flood Control	14	4425	335	13	33280	Marsh Creek	Grazing Cropland	None	None	--	--
	17	San Pablo	East Bay Municipal Water District	Municipal Recreation	57	43000	866	47	20480	San Pablo Creek	Recreation Open Space Grazing	Sedimentation	Grazing Density Control	--	Avg. rate of Sedimentation/yr 170,000 cu/yd for Past 10 yrs.

COUNTY	LAKE IDENTIFICATION				LAKE CHARACTERISTICS						LAKE AND WATERSHED MANAGEMENT				COMMENTS
	Map ID#	RESERVOIR	OWNER	EXISTING BENEFICIAL USES	AGE (yrs)	STORAGE CAPACITY (acre ft)	SURFACE AREA (acres)	AVERAGE DEPTH (feet)	DRAINAGE AREA (acres)	STREAM	LAND USE IN WATERSHED	PROBLEMS IDENTIFIED IN RESERVOIR	MITIGATION MEASURES	COSTS ($)	
MARIN	18	Alpine	Marin Municipal Water District	Municipal Recreation	60	9000	219	41	4774	Lagunitas Creek	Natural, 1 golf course	Algae Low Dissolved Oxygen	Copper Sulfate	--	Problems Considered Insignificant
	19	Bass	Pt. Reyes National Seashore	Recreation Wildlife	Natural	UNAVAILABLE				Surface Runoff	Natural	--	--	--	--
	20	Bon Tempe	Marin Municipal Water District	Municipal Recreation	29	4000	130	31	640	Lagunitas Creek	Natural	Algae Low Dissolved Oxygen	Copper Sulfate	--	Problems Considered Insignificant
	21	Crystal	Pt. Reyes National Seashore	Recreation Wildlife	Natural Lake	UNAVAILABLE				Surface Runoff	Natural	--	--	--	--
	22	Kent	Marin Municipal Water District	Municipal Recreation	24	16500	300	55	7360	""	""	Algae Low Dissolved Oxygen	Copper Sulfate	--	Problems Considered Insignificant
	23	Lagunitas	""	""	105	500	23	22	1094	""	""	""	""	--	""
	24	Nicasio	""	""	17	22000	869	25	23232	Nicasio Creek	Grazing Low Density Residential	Sedimentation	Dredging, Watershed Protection Agreements	$20,000/ year	Agreements between land owners & water district to control surface runoff
	25	Pelican	Pt. Reyes National Seashore	Recreation Wildlife	Natural Lake	UNAVAILABLE				Surface Runoff	Natural	--	--	--	--
	26	Phoenix	Marin Municipal Water District	Municipal Recreation	72	528	25	21	1354	Ross Creek	Natural	Algae Low Dissolved Oxygen	Copper Sulfate	--	Problems Considered Insignificant
	27	Soula Jule	""	Municipal		10560	310	34	12160	Walker Creek	Grazing		Purchasing land boardering lake	$2 mil.	Dam height being increased. Lake in transition
	28	Stafford	North Marin Co Water District	Municipal Recreation	26	4500	200	23	5120	Novato Creek	Recreation Grazing	Sedimentation	Dredging, Buffer Zone Purchase, Land Restoration & Erosion Control	$580,000 50% EPA 50% Water District	Part of Clean Lakes Program by EPA
	29	Wildcat	Pt. Reyes National Seashore	Recreation Wildlife	Natural Lake	NOT AVAILABLE				Surface Runoff	Natural	--	--	--	--

COUNTY	LAKE IDENTIFICATION				LAKE CHARACTERISTICS						LAKE AND WATERSHED MANAGEMENT				COMMENTS
	Map ID#	RESERVOIR	OWNER	EXISTING BENEFICIAL USES	AGE (yrs)	STORAGE CAPACITY (acre ft)	SURFACE AREA (acres)	AVERAGE DEPTH (feet)	DRAINAGE AREA (acres)	STREAM	LAND USE IN WATERSHED	PROBLEMS IDENTIFIED IN RESERVOIR	MITIGATION MEASURES	COSTS ($)	
NAPA	30	Bell Canyon	City of St. Helena	Municipal	18	2530	76	33	3584	Bell Creek	Natural Grazing	Algae, Turbidity, Odor	Designing Water Treatment Plant	$1.5 million	Problems present since completion of lake
NAPA	31	Camille	Napa State Hospital	Recreation Fire Protection	97	61	3	20	64	Springs	Natural	None	--	--	--
NAPA	32	Curry	City of Vallejo	Municipal	53	10500	419	25	10880	Gordon Valley Creek	Grazing Natural	None	--	--	50% of water shed owned by Vallejo
NAPA	33	Hennessey	City of Napa	Municipal Recreation	29	30000	850	35	32000	Conn Creek	Grazing, Cropland, Low Density Residential	Total Coliform MPN = 2400 No pesticide change in water qual. in 14 yrs.	Co. Planning Commission allows city to respond to develop. in watershed	--	City succssful in preventing motorcycle use in watershed
NAPA	34	Hinman	Veterans Home	Agriculture	69	39	2	20	179	Surface Runoff	Grazing (not being used)	None	--	--	--
NAPA	35	Marie	Napa State Hospital	Recreation	69	326	UNAVAILABLE		768	Surface Runoff	Hospital Grounds	None	--	--	Being sold to Napa Co. as open lands aquisition
NAPA	36	Milliken	City of Napa	Muncipal	54	2000	50	40	7040	Creek	Very Low Density Residential	None	See Hennessey Above	--	Water Quality has improved over 50 yrs
NAPA	37	Rector	State Dept. of Finance	Municipal Recreation	31	4400	90	49	7040	Rector Creek	Natural	Algae	Copper Sulfate Watershed Purchased Partially.	N/A	Administered by Veterans Home
S. F.	38	Lake Merced	S.F. Water District	Recreation	Natural Lake	7870	323	24	5120	Local Runoff	Urban	Algae Bacteria Solids & Floatables	Copper Sulfate &	-- --	Completely Urban Watershed

COUNTY	LAKE IDENTIFICATION				LAKE CHARACTERISTICS						LAKE AND WATERSHED MANAGEMENT				COMMENTS
	Map ID#	RESERVOIR	OWNER	EXISTING BENEFICIAL USES	AGE (yrs)	STORAGE CAPACITY (acre ft)	SURFACE AREA (acres)	AVERAGE DEPTH (feet)	DRAINAGE AREA (acres)	STREAM	LAND USE IN WATERSHED	PROBLEMS IDENTIFIED IN RESERVOIR	MITIGATION MEASURES	COSTS ($)	
SAN MATEO	39	Lower Crystal Springs	S.F. Water District	Municipal Wildlife Refuge	89	54000	1492	36	16000	San Mateo Creek	Natural	Algae	Copper Sulfate Micro-biologist	$48/100# ------ $15,000/y	City (S.F.) hired micro-biologist to study algae
	40	Pilarcitos	""	""	111	3000	109	26	2432	Pilarcitos Creek	""	None	--	--	--
	41	San Andreas	""	Municipal Wildlife Refuge Recreation	107	18500	550	34	2815	Surface Runoff	""	""	--	--	--
	42	Sears-ville	Stanford Univ.	Wildlife Refuge	87	952	90	11	9600	Corte Madera Creek	Residential	Sedimentation	None	--	Stanford is allowing situation to continue to study biology of lake
	43	Upper Crystal Springs	S.F. Water District	Municipal Wildlife	100	15500	--	--	--	San Mateo Creek	See Lower Crystal Springs (Above)				

COUNTY	LAKE IDENTIFICATION				LAKE CHARACTERISTICS						LAKE AND WATERSHED MANAGEMENT				COMMENTS
	Map ID#	RESERVOIR	OWNER	EXISTING BENEFICIAL USES	AGE (yrs)	STORAGE CAPACITY (acre ft)	SURFACE AREA (acres)	AVERAGE DEPTH (feet)	DRAINAGE AREA (acres)	STREAM	LAND USE IN WATERSHED	PROBLEMS IDENTIFIED IN RESERVOIR	MITIGATION MEASURES	COSTS ($)	
SANTA CLARA	44	Almaden	S.C. Valley Water District	Municipal Recreation Groundwater	41	1780	59	30	7680	Alamitos Creek	Recreation, Grazing	None	--	--	--
	45	Anderson	""	""	27	91280	1240	74	123520	Coyote Creek	Recreation, Grazing	None	--	--	--
	46	Calaveras	S.F. Water District	Municipal	52	100000	1450	69	64000	Calaveras Creek	Natural, Grazing	Algae	Copper Sulfate	--	--
	47	Calero	S.C. Valley Water District	Municipal Recreation Flood Control	42	10160	342	30	4416	Calero Creek	Recreation, Grazing,	High Mercury Levels in Fish ©	Warning posted at reservoir re: high levels of mercury in fish	--	Abandoned mercury mines in watershed
	48	Cherry Flat	City of San Jose	Municipal Recreation	41	500	25	20	1600	Penitencia Creek	Grazing, Recreation	Sedimentation ©	None	--	Capacity reduced by estimated 10-15%
	49	Chesbro	South S.C. Valley Water Control District	Flood Control Recreation Groundwater Recharge	22	10000	265	38	17280	Llagas Creek	Recreation, Grazing	None	--	--	--
	50	Cotton-wood	S.C. Park & Rec. Dept.	Recreation	10	Unavailable				Coyote Creek	Grazing, Recreation	None	--	--	--
	51	Coyote	S.C. Valley Water District	Municipal Flood Control Agriculture Recreation	41	23700	636	37	74240	Coyote Creek	Grazing, Recreation	None	--	--	--
	52	Elsman	San Jose Water Works	Municipal	27	6200	96	65	6400	Los Gatos Creek	Natural	Algae	Copper Sulfate	--	--

COUNTY	LAKE IDENTIFICATION				LAKE CHARACTERISTICS						LAKE AND WATERSHED MANAGEMENT				COMMENTS
	Map ID#	RESERVOIR	OWNER	EXISTING BENEFICIAL USES	AGE (yrs)	STORAGE CAPACITY (acre ft)	SURFACE AREA (acres)	AVERAGE DEPTH (feet)	DRAINAGE AREA (acres)	STREAM	LAND USE IN WATERSHED	PROBLEMS IDENTIFIED IN RESERVOIR	MITIGATION MEASURES	COSTS ($)	
SANTA CLARA (con't)	53	Felt	Stanford Univ.	Agriculture Research	47	900	UNAVAILABLE		128	Tributary to Trancos Creek	Natural	Sedimentation	None	--	--
	54	Guadalupe	S.C. Valley Water District	Municipal Groundwater Recharge	42	3740	79	47	3840	Guadalupe Creek	Grazing Recreation	None	--	--	--
	55	Lexington	""	Flood Control Recreation	24	20210	430	47	23616	Los Gatos Creek	Grazing Recreation	None	--	--	--
	56	North Fork (Pacheco)	Pacheco Pass Water District	Groundwater Recharge	38	6150	197	31	44160	Pacheco Creek	Grazing	None	--	--	--
	57	Sandy Wool	S.C. Co. Parks & Rec. Dept.	Recreation	9	UNAVAILABLE				Surface Runoff	Grazing Recreation	Aquatic Weeds	Diquat	--	--
	58	Stevens Creek	S.C. Valley Water District	Municipal Groundwater	42	3600	92	39	10880	Stevens Creek	Grazing Recreation	None	--	--	--
	59	Uvas	""	Flood Control Recreation	20	10000	280	36	19200	Uvas Creek	Grazing Recreation	None	--	--	USGS measured ave of 31150 tons of sediment entering over 3 yr period
	60	Vasona	""	Recreation Control Dam below Lexington	42	410	58	7	28800 (23616 controlled by Lexington	Los Gatos Creek	Recreation	None	--	--	--

SURFACE RUNOFF MANAGEMENT PLAN

STATUS REPORT NO. 1

GOAL, ORGANIZATION, PRODUCT, AND PROGRESS

YORAM J. LITWIN
B. J. MILLER

FEBRUARY 2, 1977

ASSOCIATION OF BAY AREA GOVERNMENTS

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INTRODUCTION

This is the first of four briefs on the Surface Runoff Program. Each brief will emphasize a different aspect of the program. This brief emphasizes the goals and organization. The other three will cover the following:

- problems caused by surface runoff
- alternatives for solving the problems
- the preliminary regional Surface Runoff Management Plan.

Each brief will also include a progress report, preliminary conclusions, and an up-to-date estimate of what the final plan will be.

This brief describes the program and identifies a fundamental issue for EMTF action. The issue and action are summarized below and described in more detail in the next section.

ISSUE: Water quality standards have been adopted by regulatory agencies. Most of these standards, however, are stated in general terms. They do not define specific programs for surface runoff management. These standards would accommodate a wide range of options, from doing almost nothing to spending billions of dollars. If the objective were to develop a plan to achieve only water quality, the lack of adopted, definitive standards would be an enormous disadvantage. It is an advantage, though, for a program whose objective is to balance environmental benefits with social and economic costs. Definitive standards would prescribe within narrow limits both the benefits and the costs. This would virtually eliminate the possibility of balance. The issue is: Given the fact that most of the adopted standards are general, and given the objective of a balanced plan, how should plan development proceed?

ACTION: Given the goal of the Environmental Management Program, the following approach is adopted for development of the Surface Runoff Management Plan:

1. Determine all the reasonable possibilities for controlling pollution from surface runoff. (Candidate control measures, sent to EMTF in July, are included in Appendix B).

2. Identify the factors that should be considered in deciding whether a control is appropriate. (Assessment Checklist already adopted by EMTF).

3. Decide in general what problems are being caused by surface runoff; that is, what pollutants are being discharged, how much, where, generally what are their effect, what is the source of the pollutants, etc. The analysis should give strong consideration to possible effects on the Bay. (To be done by counties and ABAG, approved by EMTF).

4. Based on the problem analysis and using the assessment checklist, refine the list of candidate control measures. Develop alternative management programs. Analyze the programs with respect to the assessment checklist. Refine and reanalyze the programs. Continue this process until a set of reasonable alternatives has been developed. (To be done by counties with ABAG assistance, approved by EMTF).

5. Develop regional alternatives and assess these with respect to the assessment checklist. (To be done by ABAG with county assistance).

6. Evaluate and select among the alternatives, balancing environmental, social and economic effects. (Initially done by some counties, then by EMTF).

This brief consists of the following sections:

Goal, Objectives, and Standards: Describes the goal and objectives. Presents the adopted standards and a description of how they relate to surface runoff.

Approach: Describes the approach being taken to develop a surface runoff management plan. Gives reasons for the approach.

Organization and schedule: Describes the organization of counties and other agencies, consultants, and ABAG, and the schedule of work.

Final Product: Describes the schedule and estimates of what the final product (the plan and the continuing planning process) will be.

Progress: Describes completed work and work in progress.

Program Problems: Identifies problems and describes what actions have been taken or are needed to correct the problems.

Advisory Committee Comments and Staff Responses: Lists the comments of advisory committees on material in this report. Also lists ABAG staff responses to the comments. (In accordance with ABAG by-laws and EMTF action, advisory committees are advisory to staff).

GOAL, OBJECTIVES, AND STANDARDS

The goal of the surface runoff management program is the same as the goal for the entire Environmental Management Program, namely, to produce a plan with the following characteristics:

- It will lead to the greatest possible improvement in water and air quality and problems caused by solid waste, and will lead to compliance with federal and state standards and objectives at the earliest possible date.

- It will not have social, economic, or environmental effects so unacceptable as to prevent implementation.

There are two important aspects to this goal. First, the primary purpose of the plan is to solve environmental problems. For the surface runoff plan, this means solving water pollution problems caused by surface runoff. The plan must also lead to compliance with standards at the earliest possible date. Note that problems are not necessarily defined in terms of standards. Most of the standards are stated in general terms, as discussed later in this section. The standards, therefore, do not provide a convenient basis for definition of problems.

The second aspect of the goal is that it requires a balancing of environmental, social and economic benefits and costs. The plan for controlling surface runoff pollution can only be developed by this balancing process.

The distinguishing characteristic of the plan is that its development is in essence a political decision. The extent of the environmental benefit, the degree to which the plan solves the problems, will require a value judgment by EMTF. In addition, the tolerability of the social and economic costs will also require value judgments. In other words, the decision about what recommendations will be in the plan will be based on the conclusions of decision-makers.

It should be emphasized that the distinction between this and previous environmental planning is that this process requires a weighing of the environmental, social, and economic benefits and costs. In other planning efforts, definitive standards were set initially, and these severely limited the possibility of such weighing.

The objective of the surface runoff program is twofold:

- to produce a plan in accordance with the goal

- to develop and describe a continuing planning process for solving surface runoff pollution problems.

A preliminary estimate of what the plan and the continuing planning process will be is presented later in this brief.

The adopted standards, plans, and policies are in Appendix A. Note that most of the standards and policies are non-definitive, except the standards for dissolved oxygen, bacteria, ammonia, pesticides, and chemical constituents. The standards for pesticides and chemical constituents only apply to waters for municipal or domestic use. Ammonia has not been identified as a problem with surface runoff. Definitive standards are those which can be translated into specific, relatively unique programs.

This is the case, for example, for the dissolved oxygen standard and the program of the South Bay Dischargers. The standard for dissolved oxygen is 5 mg/l. This is a tight constraint on what the South Bay Dischargers must do to solve their dry weather pollution problem. They can give their sewage some extra treatment and pipe it north to areas of greater dilution, or they can treat even more and discharge farther south. They cannot, however, do nothing. They must pay the minimum and, in some cases, relatively high costs of a program which will meet the standard. In other words, definitive standards leave some room for options, but not much. When a definitive standard has been set, the abatement program is pretty well fixed as well as the socio-economic costs of meeting the standard.

Studies made before this program began indicated that surface runoff was contributing to the violation of both of the above definitive standards. Surface runoff contributes to the occasional violation of the dissolved oxygen standard south of San Mateo Bridge. It also causes near-shore violation of the bacteria standard in some areas of the Bay. For most of the region though, these definitive standards are not being violated because of surface runoff. Compliance with all of the other, non-definitive, standards is a subjective evaluation. The determination of whether surface runoff is a "nuisance" or is causing "deleterious effects" is to a large degree a matter of opinion.

In other words, the adopted standards do not rigidly define what must be done about pollution from surface runoff. They leave room for the balancing of socio-economic and environmental factors. For surface runoff then, with few exceptions, the situation is as follows:

The goal of balancing environmental benefits with socio-economic costs should be the basis of plan development. In general, the adopted standards are not definitive and leave considerable flexibility in making the balance.

This process of balancing presents a problem for development of the surface runoff management plan. To make the balance, a range of options must be considered. Their benefits and costs must be measured. The benefits of control of surface runoff pollution will accrue in two areas, in the streams and reservoirs of the counties and in the Bay. It is likely that the benefits to the Bay will be greater than to county streams and reservoirs. Pollutants stay in the Bay longer than they do in streams. (Reservoirs are at the upper end of watersheds and tend not to be polluted.) Therefore, pollutants with long-term, cumulative effects will be more serious for the Bay than for streams.

Counties, however, will tend to base their plans on intra-county problems. Their analysis and the decisions of elected officials in the county may not give the attention to the regional problem--the Bay--that EMTF will give.

It is important that the county plans consider and assess options that will enable EMTF to make a regional balance. This may mean that counties will have to consider options with greater pollution control and greater socio-economic costs than appear to be necessary from an analysis of the problems in the streams and reservoirs of the county. The recommended action addresses this point.

APPROACH

There are three major characteristics of the approach for plan development. These are listed below:

- The plans should be developed by local agencies and then compiled and if necessary, adjusted to make up a regional plan. This should be done within the two-year planning period.
- The plans should be developed on a county-by-county basis.
- Several aspects of plan development should be done by ABAG for reasons of efficiency or consistency or to insure a carry-over of capability to the continuing planning process.

In the remainder of this section each characteristic is restated. The restatement is followed by the reasoning behind the characteristic.

The plans should be developed by local agencies and then compiled and, if necessary, adjusted to make up the regional plan. This should be done within the two-year planning period.

Programs for solving the pollution problems of municipal dischargers are now being implemented throughout the region. These programs are the result of three major planning efforts. The first was the Bay-Delta Plan, completed in the late 1960's. It was developed by a consultant to the State Water Resources Control Board. There was little involvement of local agencies in plan development. The plan was very unpopular with these agencies, and almost none of its recommendations were carried out.

The State Board then "encouraged" groups of local agencies to develop their own plans. These so-called sub-regional studies were carried out over the first half of this decade. They were the second major planning effort. Most resulted in implementable programs. Then, in 1975, the Basin Plan, the third planning effort, adjusted and ratified the sub-regional studies. The Basin Plan spells out the two-billion dollar regional program now being implemented.

Surface runoff management is now at the stage where municipal sewerage management was before the Bay-Delta study. Little has been done, and an implementable, regional plan, albeit an "initial plan," must be developed, in this case within two years. It was decided that the first planning effort for surface runoff should be analogous to the first one that worked for municipal sewerage facilities; plans should be developed first by implementing agencies, not be a regional agency or its consultant. In other words, eliminate the first planning effort, the one that proved to be unsuccessful, for municipal sewerage facilities, and use the successful second and third steps. After plans have been developed by local agencies the next step is to compile and, if necessary, adjust them to form the regional plan.

These two steps, plan development by local agencies and then compilation-adjustment, have been scheduled for the first 20 months of the two years. Local agencies will develop plans by the end of August, 1977 (14 months). Then ABAG and these agencies will compile and adjust the plans (six months).

Having local agencies develop the surface runoff plan has another major benefit. it insures their considerable involvement in the entire Environmental Management Program. Under their contracts with ABAG, local agencies are collecting data to support the entire program. They are also conducting local public participation programs. About one million dollars is being given to local agencies for this work. Development of the surface runoff plan i , then, the vehicle for local agency involvement in the Environmental Management Program.

The plans should be developed on a county-by-county basis.

Once the decision had been made to have plans developed by local agencies, the question was which grouping of local agencies. Obviously, there were too many cities to contract with. The logical choice was counties. There are a reasonable number of counties. Each county has a flood control district or division, which dealt with surface runoff. Each county also has a planning department. Therefore, local agencies were approached county-by-county, initially through the county administrator. The county administrators convened the agencies in the county. These agencies then decided how they should be organized to carry out the work, they also decided which agency should contract with ABAG. These contracting agencies are termed "lead agencies," as in "Get the lead out!" Because San Francisco already has a surface runoff management plan (to solve its combined sewer problem), no plan should be prepared for that county. Several aspects of plan development should be done by ABAG for reasons of efficiency or consistency or to insure a carry-over of capability to the continuing planning process.

Having all aspects of plan development carried out independently by each county, while giving the maximum assurance of having an implementable plan, is not the most efficient way to produce a regional plan. Nor is it the best way to insure regional consistency in the plan. Nor does it provide for carry-over of capability to the continuing planning process. Therefore, it was decided that some aspects of plan development should be carried out by ABAG. These are listed below:

- Projections of population, land use, and employment should be made by ABAG and used by all counties.
- Mathematical modeling relating the quality and quantity of surface runoff to activities on land should be provided as a service to counties by ABAG and its consultant. This capability will be a key part of the continuing planning process.
- Each county should consider the same control measures for surface runoff. These have been developed by ABAG.
- Each county should assess their management programs with respect to the same set of criteria using the same assessment procedures. The "checklist of assessment categories" has been adopted by EMTF. A manual of assessment procedures is now being prepared.
- The counties' work should be actively coordinated by ABAG to insure that consistent plans are produced by the end of August.

ORGANIZATION AND SCHEDULE

The organizational chart of the Surface Runoff Management Program is shown in Figure 1*. The key feature is the involvement of local governments in plan development.

Despite counties' responsibility to prepare their own county-wide surface runoff program; all work is being done as though it were a single program. It is directed by a single person, Dr. Yoram J. Litwin. The work is being done collectively by county personnel, consultants, and ABAG staff under his direct supervision.

The total budget of this program is over one million dollars ($1,039.817). It consists of five major program elements:

(1) <u>All county Surface Runoff Management Plan ork including water quality data collection</u>. The budget is $759,907.
The objective is to develop a reasonable management plan agreeable to ABAG and to local governments in each county. The work tasks and their schedule is shown on Figure 2. Completion of these tasks should lead to:

- description of county surface runoff problems
- recommendation of short and long-term cost-effective means of solving these problems.
- specification of the financial and institutional mechanisms needed for implementation
- the counties' recommendations for the continuing planning process

(2) <u>Consultant contract in support of mathematical modeling of surface runoff quantity and quality</u>. The budget is $174,010.
The consultant's assistance (Metcalf & Eddy, Inc. of Palo Alto in association with Resource Management Associates of Lafayette) is given in two ways:

- service-oriented assistance--includes set-up of mathematical models on ABAG computer facilities, and training and guidance to the counties on models' usage
- product-oriented assistance--consists of preparing a draft report on their analyses (specified by the contract) in support of county work.

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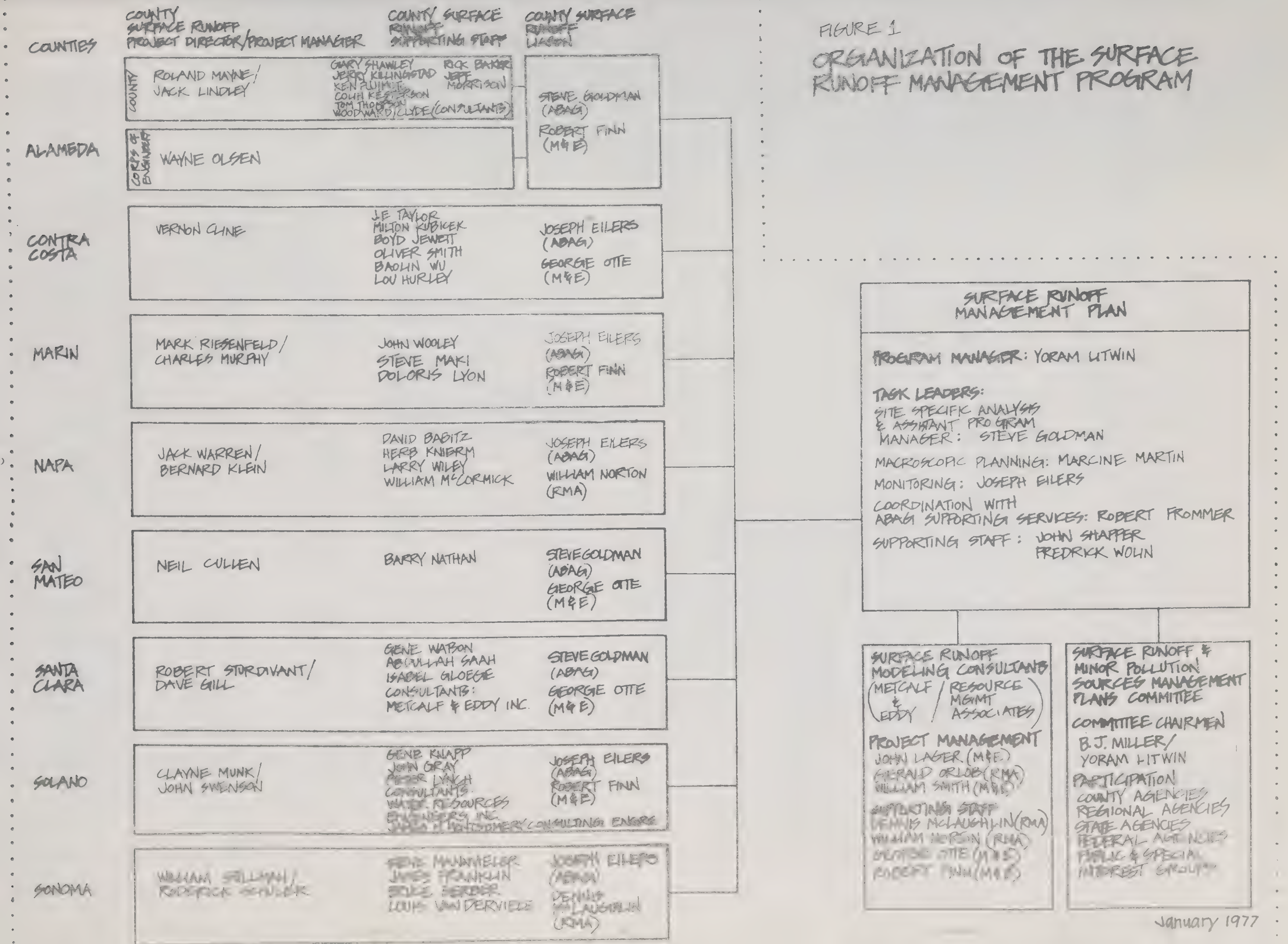
*For details, see Issue Paper No. 1 - "Operational Structure of the Surface Runoff Management Program", dated November 30, 1976. It specifies organizational charts of individual counties, consultants, and ABAG, and provides biographical sketches of their staff.

FIGURE 1

ORGANIZATION OF THE SURFACE RUNOFF MANAGEMENT PROGRAM



January 1977

(3) Administration, coordination, and supporitng services to the counties by ABAG staff. The budget is $97,500.
It includes a sequence of technical workshops, working meetings with county staff and consultants, furnishing written materials and documents to counties, identifying common problems, exchanging information on findings, and modifying work programs whenever needed. Some of the specific supporitng services include:

- assistance in mathematical modeling of surface runoff
- design of water quality sampling program, training of county personnel to carry it out, and follow-up on program execution.
- development of background information about candidate control measures
- coordination with other supporting services provided by ABAG, such as assessment and evaluation, land use, population and employment projections, mathematical modeling of the Bay, and data development on institutions and financing.

(4) Contract with USGS for work in support of plan development. The budget is $8,900.
This contract serves the following objectives:

- assistance in training county personnel to carry-out water quality sampling program
- furnishing published and unpublished USGS data and information in support of county efforts to identify pollution problems caused by surface runoff
- furnishing special streamflow data collected at USGS monitoring stations.

(5) Work of Surface Runoff Advisory Committee. Work of all committee members is voluntary.*
This committee consists of the following sub-groups:

- Advisory group--a non-voting body representing local, regional, state and federal agencies, and representatives of various special and public interest groups. Its role is to (1) review and advise on the overall work direction and progress, (2) review and comment on interim products and final plans, and (3) represent the point of view of government agencies, public, and special interest groups.

- Coordination group--a working unit of the managers of each county's surface runoff program. Its role is to assist in work coordination in and among the participating counties.

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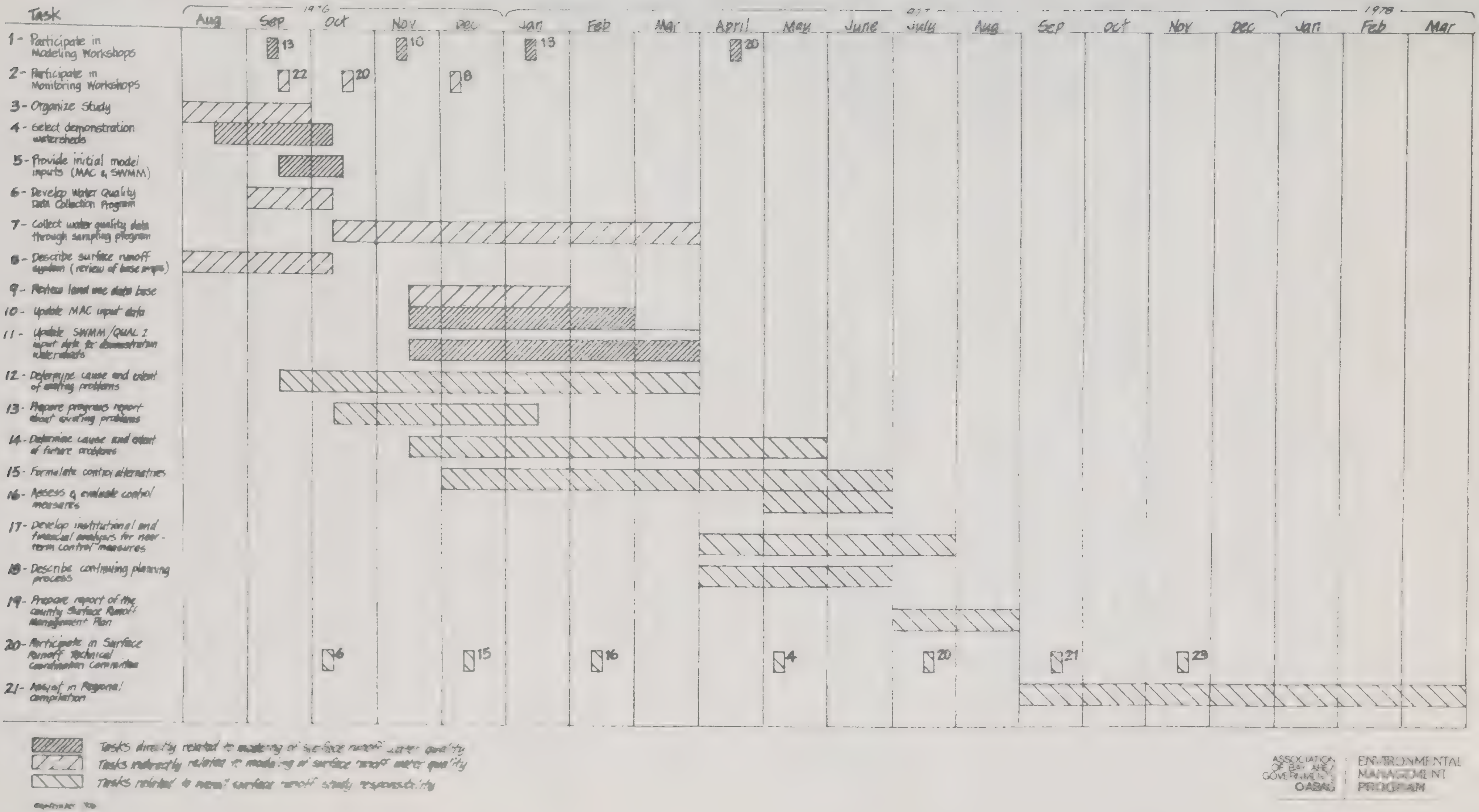
*Except the participating county and ABAG staff and the representatives of consultants and USGS.

FIGURE 2

SURFACE RUNOFF MANAGEMENT PROGRAM

county Work Schedule



ASSOCIATION OF BAY AREA GOVERNMENTS ABAG | ENVIRONMENTAL MANAGEMENT PROGRAM

FINAL PRODUCT

This section consists of an estimate of what the final plan will be. This estimate is based on very preliminary information. It is not presented to foreclose options; now have been foreclosed. The purpose of the estimate is to give EMTF and others a sense of the final product.

In general, the Surface Runoff Management Plan will consist of control measures and the governmental organization and the funding arrangements necessary to implement the control measures. It will also include a description of the continuing planning process for surface runoff management. This will be an "initial plan" and will concentrate on near-term, non-structural controls.

An estimate of some of the specifics of the plan is as follows stated in terms of <u>what</u> will be recommended, <u>who</u> will implement, <u>when</u>, <u>how</u> it will be <u>financed</u>, <u>how</u> it will be <u>regulated</u>, and <u>how</u> <u>planning</u> will proceed.

<u>WHAT</u>: The plan will consist of decisions about each of the candidate control measures. One of three decisions will be made about each measure, "yes", "no", or "maybe." If the decision is "no", the reason the control measure was ruled out will be documented. If the decision is "yes", the specifics of the measure will be described. The institutional-financial measures for carrying it out will also be described. If the decision is "maybe", the future steps leading to a "yes" or "no" decision will be described. These steps will include such things as more runoff sampling, more assessment of the costs of the measure, pilot studies of the measure's effectiveness, and steps to remove barriers to implementation through new legislation, regulations, or ordinances. Some such steps will be a part of the continuing planning process.

It is also likely that regional policies will be derived from the analysis used to make the "yes" and "maybe" decisions. Two likely policies are as follows:

- o Control of pollution by surface runoff from urban areas is essential to the protection and enhancement of the waters of San Francisco Bay. Programs of control should be developed and implementation should begin before 1983 for all urban areas in the region.

- o Control of pollution by surface runoff from developing areas is effective and can be accomplished at relatively low cost. No development of land should take place without accompanying measures to minimize water pollution by surface runoff.

There may be a greater need for controls in the southern counties than from the northern counties in the region. Pollutant loadings are higher from these counties. Also, there is less dilution of wastes in the southern reach of the Bay than elsewhere.

Controls will be most likely for urban-industrial areas because these areas generate much more pollution. Controls in developing areas will not be nearly as effective as those in built-up areas in terms of the total

pollution load from the region. However, these controls can be "built-in" to new urban development. Their socio-economic costs are expected to be low. In addition, while the benefits are not extensive, benefits to costs will be high. These kinds of controls are inexpensive. In essense, they are very cost-effecting.

Of the four categories of pollution controls (see Appendix B), measures to reduce the accumulation of pollutants on the land will have the highest priority because their costs are relatively low. Measures to reduce the amount of pollutants and peak flow or volume of runoff will have the next priority. Special measures to control surface runoff ought better land management will be proposed. Measures to treat and store runoff will probably not be recommended because of their expense. Such measures will likely be recommended for study in areas with poor dilution, such as south of Dumbarton Bridge, the Livermore-Amador Valley, and possibly the Petaluma and Napa River basins.

WHO: Existing agencies have the authority to implement almost all of the control measures. It is probable that the creation of new implementing agencies will not be recommended. Controls will be implemented by cities, counties, special districts such as flood control and resource conservation districts and State agencies such as the Division of Forestry. The implementing network will probably not be simple; it will reflect the governmental complexity of the region.

WHEN: Implementation of recommended controls will be called for within five years to meet the 1983 Federal goal of "fishable, swimmable waters where attainable. Some longer range programs will also be called for, especially those which could lead to capital-intensive, structural measures.

HOW FINANCED: The initial plan will probably be financed by the implementing agencies. Regional financing mechanisms such as tax-sharing or regional bonds will likely be long-range programs and will not apply to implementation of measures in the next few years. There is a possibility that current Federal-State grant programs (the "201" program) will apply to some measures and will offset local capital, but not operation-maintenance, costs. There is also a high probability that the 176 "208" agencies in the country will conclude that Federal funding is necessary to solve the surface runoff pollution problems. It is therefore likely that the plan will contain some options with higher financial cost and greater environmental benefits; these options would be contingent on different levels of Federal-State funding. It will likely be concluded that it would be inappropriate to produce a plan that is contingent on Federal-State funding. There may also be a conclusion that it would be inappropriate for the region to have no plan for the wise expenditure of federal-state funds if they were available.

HOW REGULATED: Based on the existing regulatory situation, the initial plan would be carried out under reulations of the Regional Water Quality Control Board backed up by State Board and EPA regulations. These regulations would

include a permit system for stormwater discharges to the Bay and several of its major tributaries. Under this arrangement the Regional Board would monitor plan implementation. These regulations, however, would probably be carried out under general guidelines included in the Environmental Management Plan. The plan would include a determination of the appropriate balance of surface runoff controls and their socio-economic costs.

HOW PLANNED: Obviously, specific planning would be required of the implementing agencies, some individually, some in groups. The continuing planning process will probably have several other major characteristics:

- o An agency will carry out regional surface runoff planning, as well as coordinating any planning by implementing agencies. This agency will use and refine the techniques developed in the preparation of the initial plan.

- o There will be an annual update of the plan, as required by law. To update the plan annually, an arrangement similar to ABAG/EMTF would be required--prinicpally to ensure continued balance of environmental, social and economic benefits and costs.

PROGRESS

The first six months of plan development have been marked by initiation of the work and completion of initial tasks. The more significant results are discussed below.

1. Formulation of the Technical Approach

The technical approach for analyzing surface runoff quantity and quality was conceptually set late last summer during preparation of request for proposals (RFP) for consultant assistance in mathematical modeling. It was finalized by selecting the specific approach proposed by the firm Metcalf & Eddy, Inc. of Palo Alto (in association with Resource Management Associates of Lafayette).

This approach is characterized by a dual-level mathematical modeling analysis. One level of analysis is represented by the Macroscopic Planning Model (MAC). It looks at major watersheds (see Figure 3) and long periods of rainfall records. Precision is sacrificed for breadth of coverage and for speed and flexibility in model application. The second level of analysis is applied to select demonstration watersheds (see Figure 4). The mathematical model used is the Storm Water Management Model (SWMM). It is a far more complex model than MAC and provides a more detailed analysis of the demonstration watersheds.

The models will compliment one another. MAC is describing the relative importance of major watersheds in producing pollutants. SWMM is providing the detailed examination and in turn is producing data which are used to improve the MAC analysis. The results of both models will be used in analyzing the response of the San Francisco Bay waters to stormwater pollution.

A key element of this approach is direct involvement and continuous model use by counties. Their training and guidance is supplied as an integral part of this approach by ABAG and Metcalf & Eddy/Resource Management Associates.

2. Preparation of Base Maps

The base maps are a set of 7 1/2-minute USGS quadrangle maps. They combine the topographic, hydrologic, and water pollution-oriented data base for the entire study area, i.e , the nine-county San Francisco Bay Region, except the San Francisco County and the northern portions of Solano, Sonoma and Marin counties. The kind of information contained in these maps is shown in Figure 5.

These maps serve as standard background information on surface runoff. They are being used for the following:

- examination of hydrographic drainage systems
- assessment of the availability of water qualtiy and streamflow data
- regional evaluation of major waste load dischargers and water quality problem areas
- selection of demonstration watersheds
- designing water qualtiy data collection program

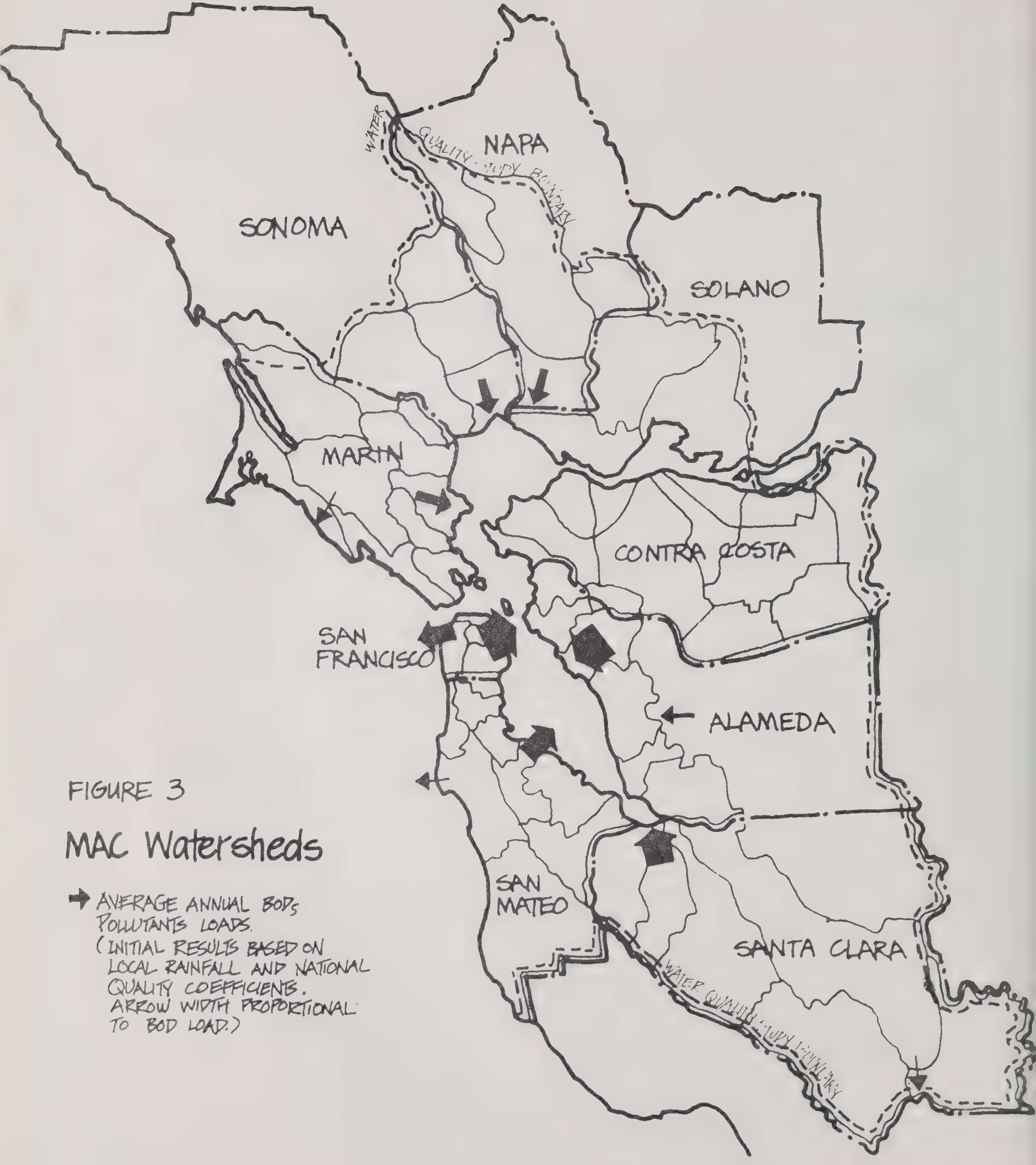


FIGURE 3

MAC Watersheds

→ AVERAGE ANNUAL BOD_5 POLLUTANTS LOADS. (INITIAL RESULTS BASED ON LOCAL RAINFALL AND NATIONAL QUALITY COEFFICIENTS. ARROW WIDTH PROPORTIONAL TO BOD LOAD.)

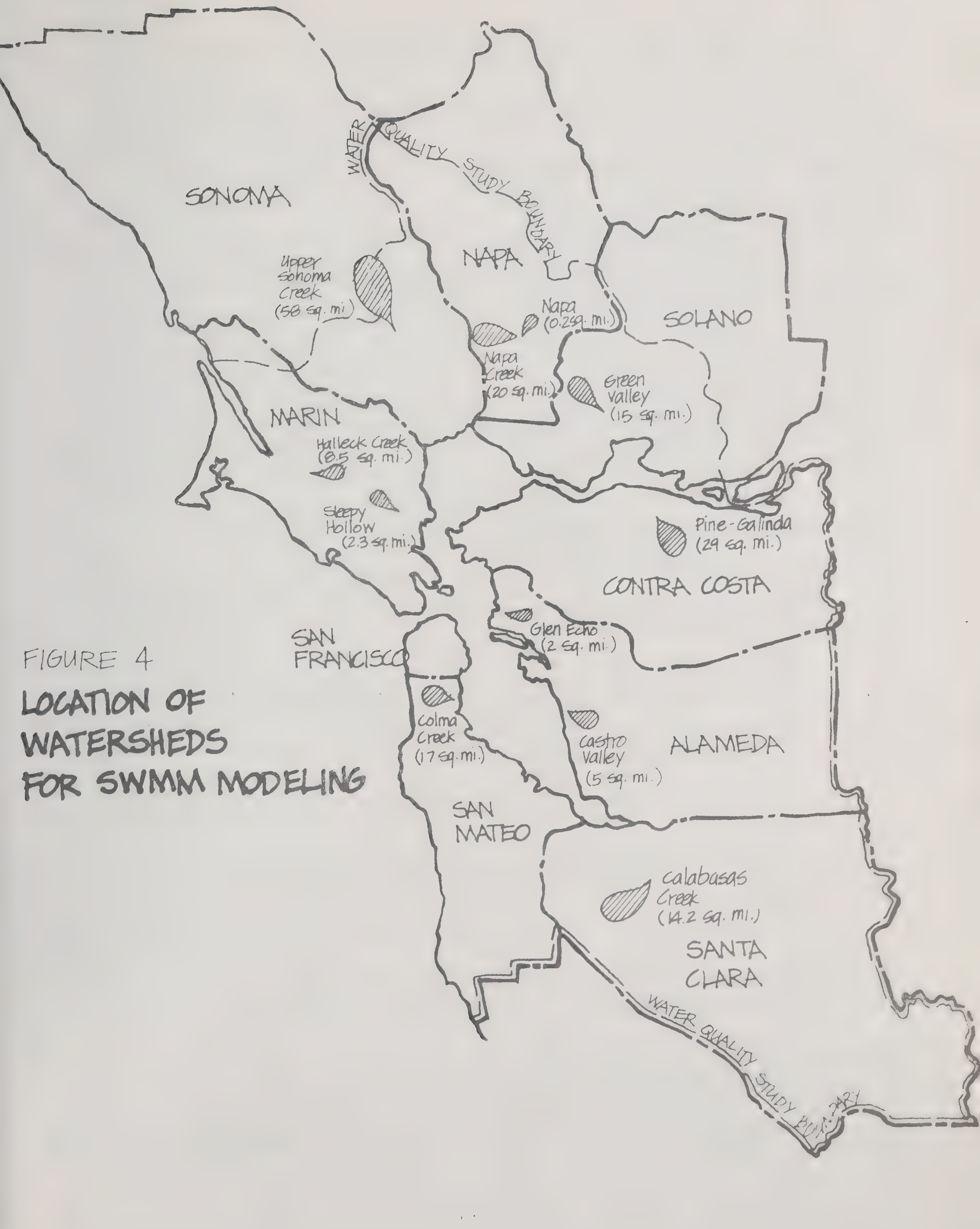


FIGURE 4

LOCATION OF WATERSHEDS FOR SWMM MODELING

3. Initial Formulation of Surface Runoff Control Measures

A preliminary list of candidate control measures has been compiled. Counties are obligated by contract to consider all these control measures. This list includes the following four categories:

- measures to reduce the accumulation of pollutants prior to runoff
- measures to control land use
- measures to reduce amount of pollutants in runoff and the peak flow or volume of runoff
- measures to store and treat runoff.

The complete list is in Appendix B. Some technical background information regarding these control measures was distributed at the Control Measures Workshop. See list of handouts in Appendix C. Additional information is being prepared.

3. Development of Regional Water Quality Sampling Program

This sampling program is the first regional surface runoff quality sampling program in the region*. The details of this program are summarized in Progress Report No. 1, "Summary of County Water Quality Sampling Programs," November 24, 1976. Program highlights are listed below:

- Total budget is $166,510 (it includes $9,300 funding from non-208 sources and $25,000 for program coordination by ABAG)
- There are 14 primary monitoring stations (to be monitored for at least three storms).
- There are 25 secondary monitoring stations (to be monitored for 1-2 storms only).
- Total number of storm runoff events to be sampled is 95 (for actual number samples collected, see Table 5).
- Average cost for one sample (core parameters only) is $61.70.

The purpose of this program is to collect data on the quantity and quality of surface runoff. The data will be used to identify relationships between activities on land the the characteristics of surface runoff.

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*In selected years from 1972 through 1975, the U.S. Army Corps of Engineers Hydrologic Engineering Center conducted a study "On the Quality of Urban Storm Runoff Entering the San Francisco Bay." Runoff from selected storms was sampled for three watersheds, Castro Valley and Peralta Creek in Alameda County and Ross Creek in San Jose.

Figure 5. INFORMATION CONTAINED ON BASE MAPS

Symbol	Description
●	- Streamflow Gauging Station
■	- Streamflow and Sediment Discharge Gauging Station
▲	- Water Quality Monitoring

Label

Agency	USGS No. 9000
Monitoring Period	1891 - (discharge), 1952-73 (quality)
Location	Alameda Creek near Niles
Nature	continuous for sed. conc., quarterly for particle size
Type of Data	daily and peak discharge, sediment, dissolved solids, chloride, N, common ions, hardness, minor elements, temp., sp. cond., pH

Symbol	Description
Ⓡ	- Rainfall Gauging Station Hourly Time Intervals
R	- Rainfall Gauging Station Other Time Intervals

STATION NAME NUMBER, AND ELEVATION	Curtner Ranch D10-2232-10 650'
PERIOD OF RECORD	1964 - present
MISSING YEARS	-
SOURCE OF DATA	Santa Clara County Water Conservation District

Symbol	Description
E	- Evaporation Gauging Station

STATION NAME AND ELEVATION	Joice Island 10'
PERIOD OF RECORD	1955 - 1959
TYPE OF PAN	Class A
SOURCE OF DATA	National Weather Service

Symbol	Description
➡	- Waste Load Outflow Location

Discharger	Chateau St. Jean Winery
Source of Data	RWQCB
Description	Up to 1 MG of treated winery waste annually discharged to land for irrigation or frost protection.

Symbol	Description
★	- Problem Area

Item	Near Oaks & Orinda
Source of Data	Co. Health Dept.
Description	Areas served by septic tanks; potential problem.

The locations and approximate sizes of the watersheds chosen for monitoring are shown in Figure 6. The characteristics of these watersheds are presented in Progress Report No. 1. The selected watersheds present a full range of sizes, terrain, and uses. The parameters for which samples will be analyzed are listed in Table 1. The selected parameters indicate balance among various parameter groups such as nutrients, solids, bacteria, organics, metals, and pesticides.

The total budget for this program ($166,510) is modest given the complex system being sampled. It constitutes about 15% of the total funding of the Surface Runoff Management Program. Considering that EMP is a planning program this level of expenditure for monitoring represents a proper balance when weighed against the overall objectives of EMP.

5. Technical Training

Technical training of county personnel occurs in two ways. Formal workshops are held. Also, there are numerous informal meetings among counties, consultants, and ABAG staff. This is a unique feature of the Surface Runoff Management program. Six workshops were conducted so far. They have been designed for the planners, engineers, and managers selected by the county lead agencies to carry out the county plans.

The training workshops are addressing three primary subject areas:

Mathematical modeling of surface runoff. The following three workshops were devoted to this subject.

- Workshop #1 - Introduction to Surface Runoff Modeling (9/15/76)
- Workshop #4 - Demonstration of Modeling Results (11/17/76)
- Workshop #6 - Demonstration of Model Use on ABAG Computer Facilities (1/26/77).

Design and execution of monitoring program. The following two workshops were held:

- Workshop #2 - Monitoring Techniques and Procedures (9/30/76)
- Workshop #3 - Field Demonstration of Monitoring Techniques (10/18/76).

Surface runoff control measures. Only one workshop has been held so far:

- Workshop #5 - Introduction to Surface Runoff Control Measures (12/15/76).

For each of these subject-areas a workbook was distributed to workshop participants. Handouts are added to these workbooks at successive workshops throughout the program. Listing of all handout material is given in Appendix C.

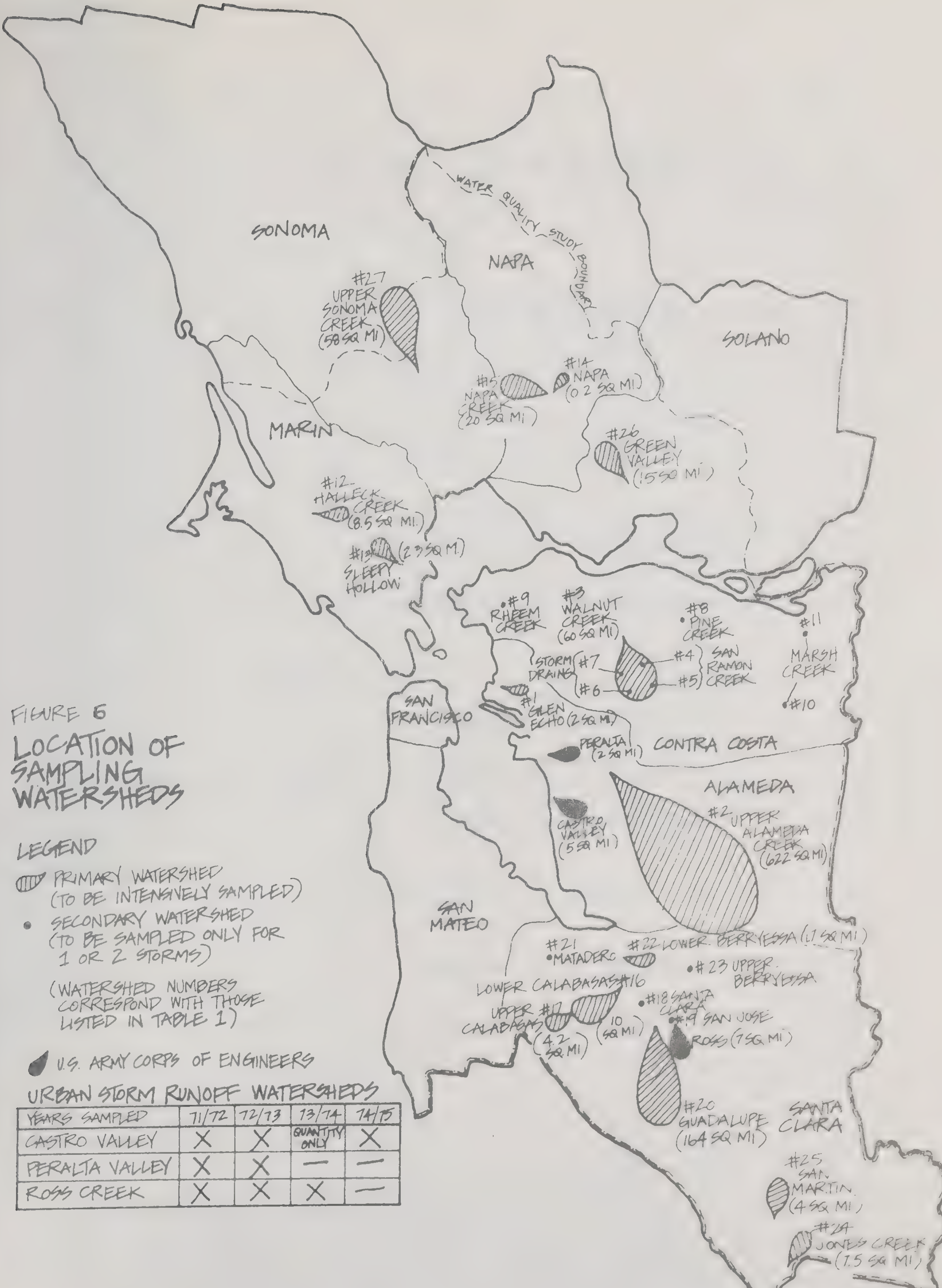


FIGURE 5

LOCATION OF SAMPLING WATERSHEDS

LEGEND

- PRIMARY WATERSHED (TO BE INTENSIVELY SAMPLED)
- • SECONDARY WATERSHED (TO BE SAMPLED ONLY FOR 1 OR 2 STORMS)

(WATERSHED NUMBERS CORRESPOND WITH THOSE LISTED IN TABLE 1)

- U.S. ARMY CORPS OF ENGINEERS

URBAN STORM RUNOFF WATERSHEDS

YEARS SAMPLED	71/72	72/73	73/74	74/75
CASTRO VALLEY	X	X	QUANTITY ONLY	X
PERALTA VALLEY	X	X	—	—
ROSS CREEK	X	X	X	—

TABLE I

SUMMARY OF SAMPLING PARAMETERS

(By Watershed)

			Alameda		Contra Costa		Marin			Napa		Santa Clara	Solano	Sonoma
		Parameters	Glen Echo	Alameda Creek	Walnut Creek	8 Others	Halleck Creek	Sleepy Hollow	10-15 Others	Upper Napa Creek	Lower Napa Creek	10 Locations	Green Valley	Sonoma Creek
core parameters	nutrients	BOD_5	●	●	●	●	●	●	○	●	●	●	●	●
core parameters	nutrients	Total Nitrogen	●	●	●	●	●	●	○	●	●	●	●	●
core parameters	nutrients	Total Phosphorus	●	●	●	●	●	●	○	●	●	●	●	●
core parameters	solids	Suspended Solids	●	●	●	●	●	●	○	●	●	●	●	●
core parameters	solids	Volatile Suspended Solids	●	●	●	●	●	●	○	●	●	○	●	●
core parameters	solids	Total Dissolved Solids	●	●	●	●	●	●	○	●	●		●	●
core parameters		Lead	○	●	●	●	●	●	○	●	●	○	●	○
spot-check parameters		COD	●	●	○	○	○	○	○	○	○			○
spot-check parameters	bacteria	Fecal Coliforms	○		○		○	○	○	●	●	○	○	●
spot-check parameters	bacteria	Fecal Streptococci	○		○		○	○	○	○	○		○	○
spot-check parameters	bacteria	Total Coliforms	○		○		○	○	○	●	●	○	○	●
spot-check parameters	metals	Cadmium			○		○	○	○					
spot-check parameters	metals	Chromium			○				○					
spot-check parameters	metals	Mercury			○		○	○	○					
spot-check parameters	metals	Zinc	○		○		○	○	○					
spot-check parameters	metals	Copper			○									
spot-check parameters	Pestcds	Total identifiable chlorinated hydrocarbons	○		○		○	○	○			○	○	○
		Number of Storms Sampled	6-8	1-2	4-6	1	4	4	1	5	5	2-4	3	8

● 5-10 samples per storm

○ 1 composite sample per storm

In addition to the workshops, ABAG staff and its consultants have held about 30 meetings with counties. The most significant result of this training is in building a uniform technical capability among the county personnel. This will promote compatibility and consistency of the different plans. More important the resulting capability of counties' staffs will be an essential feature of the continuing planning process.

6. Quantification of Pollutants Loads - Initial Results

The Macroscopic Planning Model (MAC) has been run for seven of the nine counties (exceptions are Solano and Contra Costa). Table 2 summarizes the calculated pollutants loads for individual counties. As evident from this table most of the pollution problems are associated with San Mateo, Santa Clara and Alameda counties. Examination of computer printouts on which this table is based indicates, as expected, that most pollution problems in the San Francisco Bay area are related to the urbanized land (See Figure 3).

In contrast to the MAC analysis, the site specific analysis with the Storm Water Management Model (SWMM) has not provided any significant results yet. The problem is primarily related to lack of surface runoff quality data for model calibration. The SWMM model will initially be run for 14 watersheds. They are shown in Figure 4. County progress on SWMM demonstration watersheds is summarized in Table 6.

7. Availability of MAC and SWMM Models for use by county personnel

The MAC and SWMM models have been programmed on the ABAG computer. The training of county personnel in model use has been completed. The models are now ready for independent use by county personnel. ABAG assistance in model usage will be available whenever needed. Some counties intend to install these two models on their own computer facilities. Other counties will use remote terminals for executing computer runs on ABAG computer facilities via telephone lines. Alameda County is already running SWMM in their offices.

TABLE 2

AVERAGE ANNUAL POLLUTANT LOADS TABULATED BY COUNTIES (intermediate results of MAC Model - 1/77)

COUNTY	AREA (acres)	AVERAGE ANNUAL POLLUTANT LOAD, THOUSANDS OF POUNDS				
		Biological Oxygen Demand (BOD)	Suspended Solids	Volatile Suspended Solids (1)	Total Nitrogen (2)	Total Phosphorus(2)
		1969-1970	1969-1970	1969-1970	1969-1970	1969-1970
SAN FRANCISCO	28,528	6,400	89,400	30,500	700	300
SAN MATEO	286,236	3,000	40,700	20,700	900	100
SANTA CLARA	833,332	3,700	45,500	29,200	1,000	100
ALAMEDA (Upper Alameda Creek)	395,080	400	5,000	3,200	100	10
ALAMEDA	200,313	4,100	50,800	29,400	1,000	100
NAPA	272,548	800	13,700	8,400	300	40
SONOMA	197,466	900	9,800	6,200	200	30
MARIN	298,970	1,000	14,100	8,760	300	40

(1) A measure of organic suspended solids
(2) Nitrogen and phosphorus are nutrients

PROGRAM PROBLEMS

Over the past six months a number of problems have been encountered. Some of them have already been resolved. Others are still hindering the work progress. A short discussion of these problems is presented below:

1. Late start of activities by some of the counties

   This problem is summarized in Table 3 below:

TABLE 3
DATES OF CONTRACT EXECUTION

COUNTY	DATE OF CONTRACT EXECUTION EXPECTED	ACTUAL	TOTAL BUDGET	COMMENTS ABOUT WORK DONE PRIOR TO CONTRACT EXECUTION
ALAMEDA[1]	7/1/76	10/19/76	161,191	Some work initiated
CONTRA COSTA	7/1/76	1/18/77	120,000	Attendance at workshops and mtgs. Work progress considerably impeded
MARIN	7/1/76	8/3/76	99,160	
NAPA	7/1/76	8/10/76	99,000	
SAN MATEO	7/1/76	12/76	141,000	Limited attendance at workshops and meetings. No work done
SANTA CLARA[2]	7/1/76	8/76	170,000	
SOLANO	7/1/76	10/12/76	58,000	
SONOMA	7/1/76	11/1/76	85,000	Some work initiated

[1] Contracts with County and Alameda County Flood Control and Water Conservation District signed on the same date.

[2] Includes contracts with both County and Santa Clara Valley Water District.

2. Execution of tasks and transmittal of information to ABAG and Consultants is slow

   This problem is only partially related to the late start by some counties. Table 4 summarizes the problem. It fails to give a totally accurate picture of delays because in some cases due dates were changed; only the latest due dates are shown.

   The problem of late submittals is not yet serious. It is indicative of possible future problems. The most significant deadline will be February 28, 1977 when the county progress reports "Examination of Existing Water Quality Problems", will be due.

TABLE 4

SUBMITTAL OF REQUESTED INFORMATION TO ABAG

TASK	DUE DATE	APPROXIMATE DATE RECEIVED BY ABAG Alameda	Contra Costa	Marin	Napa	San Mateo	Santa Clara	Solano	Sonoma
Review Base Maps	Oct. 6	Oct.	--	Oct. 4	Oct. 13	--	Oct.	Oct.	Oct.
Complete Questionnaire (MAC watershed input data)	Nov. 5	Nov. 1	Feb. 1	Nov. 11	Nov. 15 (preliminary) Dec. 7 (completed)	completed by ABAG	Oct. 26	Nov. 15 (preliminary)	Oct. 22 (preliminary) Dec. 13 (completed)
Prepare County Work Schedule	Oct. 22	Sept. 25	--	Nov. 24	Nov. 24	--	Oct.	Nov. 24	Dec. 4
Select Demonstration Watersheds	Nov. 17	Oct.	Jan.	Oct.	Oct.	Jan.	Dec.	Oct.	Nov. 17
Verify Table of Demonstration Watershed Characteristics	Nov. 17	Nov. 17	--	Nov.	--	--	Oct.	--	Nov. 17
Prepare Draft Sampling Program Description	Sept. 30	Sept. 30	--	Sept. 30	Sept. 30	--	Sept. 30	Sept. 30	Sept. 30
Prepare Final Sampling Program Description	Oct. 29	Oct. 29.	--	Nov.	Nov 15	--	Nov. 12	Nov. 18	Nov. 2
Prepare SWMM Input Data For First Watershed	Nov. 17	Nov. 10	--	Jan. 10	Dec. 20 (1st watershed) Jan. 15 (2nd watershed)	--	--	Jan. 20	Nov. 30 (w/o erosion data) Jan. 23 (w/erosion data)
Prepare MAC Watershed-440 Zone Correspondence Table	Dec. 15	--	--	Dec. 8	Dec. 10	completed by ABAG	Oct. 22	Dec. 17	Dec. 30
Prepare Reports On Sampling Data Collected	As soon as poss. after storm events	Jan. 5	--	Jan. 25	Feb. 1	--	Feb. 1	Jan. 31	Jan. 20
Prepare Statement of Goals of County Surface Runoff Program	Jan. 20	--	--	--	--	--	Jan. 24	Jan. 20	Jan. 20

3. Difficulty in establishing an understanding and consensus among the county lead agencies as to what the surface runoff problems are or may be.

This is a difficult issue which should be slowly resolved as the work progresses. This problem is related to several other problems. These are:

- o lack of definitive standards for surface runoff
- o lack of local data on quality of stormwater runoff
- o lack of detailed information on localized problems caused by surface runoff.

The first problem should be resolved by the EMTF action recommended at the beginning of this brief. The water quality monitoring program should provide an answer to the second problem. The county progress reports on "Examination of Existing Water Quality Problems", soon to be completed, should provide some clarification to the third problem. The information in these progress reports will be partially based on a county-wide survey of local problems.

The information provided by these surveys will be augmented by an ABAG Progress Report No. 2 "Summary of Surface Runoff Modeling Program", which will be available by mid-February. This report will discuss the results of computer simulation of pollutant loads.

4. Some counties are completely relying on the work of their consultants.

While generally it is expected that a good product will be produced by consultants, the lack of county involvement contradicts to some extent the basic concept of county participation. The consequences might be felt in the continuing planning process.

5. Lack of county initiative in preparation of the surface runoff plans.

The counties are obligated by contract to develop a Surface Runoff Management Plan. ABAG must provide certain supporting services. The counties, therefore, should have the principal responsibility of plan development.

Over the past six months, most of the initiative has been exercised by ABAG. Almost all work accomplished by counties was done in response to specific requests and deadlines set by ABAG.

6. The counties need a higher level of ABAG staff support than originally anticipated.

This problem is closely related to (5) above. As a result of this problem ABAG has increased its staff and consultant budget for the Surface Runoff Management Program. These modifications in the budget were adopted at the January EMTF meeting.

7. Lack of rain slows down data collection program.

This is a major problem. A contingency plan for dealing with this problem will be formulated soon. It will be submitted for the Surface Runoff and Minor Pollution Sources Management Plans Committee at its March 3, 1977, meeting.

The sampling done so far is shown in Table 5. Note that the amount of sampling is much less than planned. The rainy season is more than 2/3 complete.

TABLE 5
PROGRESS OF WATER QUALITY SAMPLING

DATE OF STORM	NUMBER OF SAMPLES COLLECTED IN EACH COUNTY							
	ALAMEDA	CONTRA COSTA	MARIN	NAPA	SAN MATEO	SANTA CLARA	SOLANO	SONOMA
Nov. 11, 1976	6	--	--	--	--	19	--	--
Nov. 13, 1976	--	--	--	--	--	15	--	--
Dec. 30, 1976	14	--	10	--	--	37	8	--
Jan. 1, 1977	--	--	--	--	--	--	--	9
Total Analyzed	20	--	10	--	--	71	8	9
Total Number of Samples Planned	96	38	50	--	--	192	30	64

8. Lack of data slows down calibration of SWMM model.

This problem is closely related to item (7) above. Table 8 summarizes county progress on SWMM demonstration watersheds runs.

9. The completion of Series 3 base year land use data and projections is slightly delayed.

This is not a major problem because the initial analysis is concentrating on existing conditions. Series 3 projections will be based on the 1975 base year data by 440 zones. This 1975 data base was not available in time for the initial MAC runs. Therefore, the 1970 base year data was used.

The Series 3 projections should be available in time for the analysis of future conditions. To keep the land use data for existing conditions compatible with land use projections, the same base year must be used. Therefore, the 1970 base year data will have to be replaced by the 1975 base year data prior to the final runs of the MAC model.

10. No budget is presently available for monitoring during the next rainy season (1977/78).

This is an important problem that must be resolved during the next four months. Continuity of the monitoring program is essential for developing a meaningful data base for the continuing planning process. The current monitoring program ($166,510) is almost entirely funded by EMP. The continuing planning process will describe the monitoring needs for the year 1978/79. Currently, no funds are available for monitoring during the year 1977/78. ABAG staff is exploring sources of additional money.

TABLE 6

COUNTY PROGRESS ON SWMM DEMONSTRATION WATERSHED RUNS

COUNTY AND WATERSHED	LITTLE OR NO PROGRESS	INITIAL MEETING (step 1)	SECOND MEETING (step 2)	DATA PREPARED (setp 3)	INITIAL DEMO. RUNS (step 4)	INITIAL CALIB. RUNS (step 5)	FINAL CALIB. (step 5)
ALAMEDA							
*Glen Echo						X	
□Castro Valley		X					
CONTRA COSTA							
*Pine/Galinda					X		
MARIN							
*Sleepy Hollow					X		
Halleck			X				
□Others	X						
NAPA							
*York St.					X		
Napa Cr.					X		
SAN MATEO							
*Colma Creek		X					
La Honda	X						
SANTA CLARA							
*Calabasas		X					
San Martin	X						
Berryessa	X						
SOLANO							
Green Valley					✓		
SONOMA							
*Sonoma Cr.					✓		

*First Watershed to be simulated in each County--RMA takes primary responsibility.

□Special "large-scale" watershed designed to interface with ABAG Bay Modeling Project.

ADVISORY COMMITTEE COMMENTS AND STAFF RESPONSES

To date the Surface Runoff and Minor Sources Management Plans Committee has met three times (October 6, December 17, and January 20). At the first meeting the committee was introduced to the program. The second meeting centered around a discussion of the monitoring program. This program was summarized in Progress Report No. 1 "Summary of County Water Quality Sampling Programs". The focus of the third meeting was the discussion of the goal of the surface runoff program.

Comments made by the advisory committee at these three meetings and staff responses are summarized in Table . The most significant results of the committee meetings are:

- committee reorganization and definition of the operating rules
- minor modifications in the sampling program and recommendation to secure budget for monitoring during the next season (1977/78) i.e., to act on the matter prior to plan adoption.
- recognition by the committee of the difficulties involved in plan development; recommendation to take an active role in preparing the EMTF for the task of making decisions on less than ideal information base.

The next two meetings of this committee will take place on March 3 and April 28. The major topics for discussion will be:

- a contingency plan if the drought continues
- the presentations by individual counties of their progress reports entitled "Examination of Existing Water Quality Problems".

	COMMITTEE COMMENTS	STAFF RESPONSES
MEETING OF OCTOBER 6, 1976 (1:30 p.m. - 3:30 p.m.)	1. The purpose and role of the committee not clearly understood. The Committee cannot serve the coordination and advisory roles at the same time.	1. Committee definition in EMTF manual modified. The Committee was split into coordination and advisory sub-groups. The objective of coordination group is to review progress in each county, identify common problems and other issues, and decide subsequent courses of action. The objective of the advisory group is to review progress and advise on both the conduct of study as well as recommendations from the study. The two groups meet in subsequent sessions. Both sessions are open to all committee members. Distinction is made, however, between participants and observers.
	2. The mode of committee operation must be clearly defined (decisions made by voting or consensus?)	2. This committee is a non-voting committee. It makes recommendations to ABAG staff. These recommendations are reached by consensus. Any member of the committee can raise an issue in front of EMTF. ABAG staff will make routine briefings to EMTF on committee activities and recommendations.
	3. ABAG staff should provide the committee with the following; (a) summaries of proceeding meetings, recommendation made and staff responses, (b) meeting agendas which distinguish between informational items and items for committee discussion and recommendation, and (c) list of discussion items for subsequent meetings.	3. These requests will be fulfilled for all subsequent meetings.
	4. Meeting agenda and all technical materials should be provided in ample time for review prior to meeting.	4. Attempt will be made to fulfill this request.
MEETING OF DECEMBER 17, 1976 (9:30 a.m. - 12:50 p.m.)	<u>Coordination Group</u>	
	1. ABAG should provide more guidance to the counties.	1. ABAG staff has been increased. This will result in more guidance and support to the counties.
	2. The goals of the program not well defined.	2. Disagree. This is a complex problem with several major goals. Consequently, it may appear to be somewhat undefined. The next committee meeting will focus on this subject. Counties are requested to prepare written statements of their county goals.
	<u>Advisory Group</u>	
	3. A number of questions asked regarding technical details of the monitoring program. (More monitoring for bacteria, heavy metals, effects of surface runoff on shellfish, monitoring of industrial sites insufficient, need to monitor dry weather flow.)	3. Staff response summarized in detail in Technical Memorandum No. 4, "County Water Quality Sampling Programs - Modifications and Comments The most significant responses are: (a) monitoring of additional industrial sites will be done, (b) monitoring of more heavy metals can be accomplished by storing the samples and analyzing them at a later date. The unused budgets (due to small number of storms monitored) can be used for that purpose, (c) monitoring effects of surface runoff on shellfish beds, monitoring of dry weather flow, and more monitoring of bacteria, can not be accomplished within this program due to budget restrictions.

TABLE 7 (Continued)

	COMMITTEE COMMENTS	STAFF RESPONSES
	4. Budget of about $250,000 should be secured for monitoring during the 1977/78 rainy season. The need for continuing of the monitoring program must take high priority.	4. Agree. Preliminary inquiries were made with EPA officials. The funds for this purpose can be made available by either (1) directly applying for EPA grant under R & D, or (2) requesting initiative from Region IX, supported by the State.
Meeting of January 20, 1977 (9:00 AM - 12:30 PM)	<u>Coordination Group</u>	
	1. Request is made to ABAG to clarify the task of land use data review.	1. ABAG will respond in a written statement that the scope of this task will be smaller than originally anticipated. Wherever needed, county contracts with ABAG will be modified.
	2. How the inability to collect much water quality data this year will affect program development.	2. This issue will be dealt in great detail at the next meeting of this committee. By then the monitoring season will be practically over and the amount of the collected data will be known.
	3. The time available for coordination group meetings (1½ hours) is insufficient.	3. More time will be allocated in the future.
	4. The counties cannot proceed with plan development if they cannot adequately document the problems.	4. ABAG staff agrees that this is a significant matter. The issue is - what is a problem? One definition is that a problem is a violation of standards. Because the standards are general, this definition is not of much use. A less definitive definition is appropriate. ABAG will provide information to counties on how to identify problems.
	5. County reporting on progress and expenditures should be streamlined.	5. Agree. Memo to this effect issued to all county surface runoff program directors.
	<u>Advisory Group</u>	
	6. Satisfaction expressed regarding organization of committee meetings and the handout materials distributed to committee members.	6. Thanks.
	7. Clarification asked regarding the brief presentation of the modeling program by Mr. John Lager of Metcalf & Eddy, Inc., (consultants).	7. Progress Report No. 2, entitled "Summary of Surface Runoff Modeling Program" will be available for discussion at the next committee meeting.
	8. In response to presentation by B. J. Miller about the Surface Runoff Management Plan goals the committee has recognized the difficulties facing plan development. Suggestion was made that the committee take an active role in preparing EMTF and other decisions-makers for the task of making decisions on less than ideal informational base.	8. Good idea. The discussion of plan development will be brought up for committee discussion as the work evolves and more information becomes available.

APPENDICES

A. Existing Water Quality Policies, Plans and Standards

B. Candidate Surface Runoff Control Measures

C. Surface Runoff Management Program - List of Handout Materials

APPENDIX A

EXISTING WATER QUALITY POLICIES,
PLANS AND STANDARDS

The following list of water quality policies, plans and standards is contained in the Water Quality Control Plan Report [for the] San Francisco Bay Basin (2) (April, 1975). The * indicates those items which are relevant to surface runoff.

EXISTING STATEWIDE PLANS AND POLICIES

The State Water Resources Control Board has adopted a "Statement of Policy with Respect to Maintaining High Quality of Waters in California", the "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California", the "Water Quality Control Plan for Ocean Waters of California", and the "Water Quality Control Policy for the Enclosed Bays and Estuaries of California". The Regional Board is required to implement the provisions of these plans and policies. They are briefly discussed below and are included in their entirety in a special appendix attached to this plan.

*** Nondegradation Policy**

On October 28, 1968, the State Water Resources Control Board adopted Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California". While requiring the continued maintenance of existing high quality waters, the policy provides conditions under which a change in water quality is allowable. A change must:

- be consistent with maximum benefit to the people of the State,
- not unreasonably affect present and anticipated beneficial uses of water, and
- not result in water quality less than that prescribed in water quality control plans or policies.

Thermal Plan

The "Water Quality Control Plan for the Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California", adopted by the State Water Resources Control Board on May 18, 1972, specifies water quality objectives, effluent quality limits, and discharge prohibitions related to thermal characteristics of interstate waters and waste discharges.

Ocean Plan

The "Water Quality Control Plan for Ocean Waters of California" was adopted by the State Water Resources Control Board on July 6, 1972. This plan establishes beneficial uses and water quality objectives for waters of the Pacific Ocean adjacent to the California Coast outside of enclosed bays, estuaries, and coastal lagoons. Also, the Ocean Plan prescribes effluent quality requirements and management principles for waste discharges and specifies certain waste discharge prohibitions.

The Ocean Plan also provides that the State Water Resources Control Board shall designate Areas of Special Biological Significance and requires wastes to be discharged a sufficient distance from these areas to assure maintenance of natural water quality conditions.

*** Bays and Estuaries Policy+**

The "Water Quality Control Policy for the Enclosed Bays and Estuaries of California" adopted by the State Water Resources Control Board on May 16, 1974, provides water quality principles and guidelines for the prevention of water quality degradation and to protect the beneficial uses of waters. Decisions by the Regional Board are required to be consistent with the provisions of this policy. This policy does not apply to wastes from vessels or land runoff except as specifically indicated for siltation and combined sewer flows.

WATER QUALITY OBJECTIVES

The water quality objectives which follow supersede and replace those contained in the "Interim Water Quality Control Plan for the San Francisco Bay Basin" (as updated); the "Water Quality Control Policy for Pacific Ocean, Pescadero Point to Mouth of Tomales Bay, Bolinas Lagoon, Drakes Estero, Limantour Estero, Portions of Tomales Bay, and Tidal Portions of Coastal Streams" (1967); and the "Water Quality Control Policy for Tidal Waters Inland from the Golden Gate within the San Francisco Bay Region" (1967).

*Controllable water quality factors shall conform to the water quality objectives contained herein. When other factors result in the degradation of water quality beyond the levels or limits established herein as water quality objectives, then controllable factors shall not cause any further degradation of water quality.

*Controllable water quality factors are those actions, conditions, or circumstances resulting from man's activities that may influence the quality of the waters of the State and that may be reasonably controlled.

+ Pertinent sections of this policy are included at the end of this section (see "Principles for Management of Water Quality in Enclosed Bays and Estuaries")

These water qualtiy objectives are considered to be necessary to protect those present and probable future beneficial uses enumerated in Chapter 2 of this plan and to protect existing high quality waters of the State. These objectives will be achieved primarily through the establishment of waste discharge requirements and through the implementation of this water quality control plan.

The Regional Board in setting waste discharge requirements will consider, among other things, the potential impact on beneficial uses within the area of influence of the discharge, the existing quality of receiving waters, and the appropriate water quality objectives. The Regional Board will make a finding as to the beneficial uses to be protected within the area of influence of the discharge and establish waste discharge requirements to protect those uses and to meet water quality objectives.

In general, the objectives are intended to govern the concentration of pollutant constituents in the main water mass. Obviously, the same requirements cannot be applied at or immediately adjacent to submerged effluent discharge structures. Allowable zones of dilution within which higher concentrations will be tolerated will be defined for each discharge at the time discharge permits are drafted. Expression of certain water quality objectives in the form of statistical distribution (50 and 90 percentile values) should also be considered when drafting discharge permits.

In the following section the objectives are stated and are followed in some cases by discussion of the background and rational of the objective.

General Objective

The following objectives shall apply to all waters of the Basin

* Nondegradation

Wherever the existing quality of water is better than the quality of water established herein as objectives, such existing quality shall be maintained unless otherwise provided by the provisions of the State Water Resources Control Board Resolution No. 68 16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California", including any revisions thereto. A copy of this policy is included verbatim in the "Plans and Policies Appendix".

Objectives for Ocean Waters

The provisions of the State Board's "Water Quality Control Plan for Ocean Waters of California" (Ocean Plan), and "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California" (Thermal Plan) and any revisions thereto shall apply. Copies of these plans are included verbatim in the "Plans and Policies Appendix".

In addition to the provisions of the Ocean Plan and Thermal Plan, the following objectives shall also apply to all ocean waters of the Basin:

* <u>Dissolved Oxygen</u>

The mean annual dissolved oxygen concentration shall not be less than 6.0 mg/l nor shall the minimum dissolved oxygen concentration be reduced below 5.0 mg/l at any time.

<u>pH</u>

The pH value shall not be depressed below 7.0 nor raised above 8.5.

Objectives for Inland Surface Waters, Enclosed Bays, and Estuaries

The following objectives apply to all inland surface waters, enclosed bays and estuaries of the Basin.

* <u>Color</u>

Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses.

* <u>Tastes and Odors</u>

Waters shall not contain taste or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, that cause nuisance or adversely affect beneficial uses.

* <u>Floating Material</u>

Waters shall not contain floating material, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses.

* <u>Suspended Material</u>

Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.

* <u>Settleable Material</u>

Waters shall not contain substances in concentrations that result in the deposition of material that cause nuisance or adversely affect beneficial uses.

* <u>Oil and Grease</u>

Waters shall not contain oils, greases, waxes or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses.

* <u>Biostimulatory Substances</u>

Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.

* <u>Sediment</u>

The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

* <u>Turbidity</u>

Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases from normal background light penetration or turbidity relatable to waste discharge shall not be greater than 10 percent in areas of 10 JTU or more; waters of characteristically low natural turbidity shall be maintained so that discharges do not cause visible, aesthetically undesirable contrast with the natural appearance of the water.

<u>pH</u>

The pH shall not be depressed below 6.5 nor raised above 8.5.

Changes in normal ambient pH levels shall not exceed 0.2 units in waters with designated marine (MAR) beneficial uses nor 0.5 units in fresh waters with designated COLD or WARM beneficial uses.

The above objective encompasses the pH range usually recommended by the Department of Fish and Game and is consistent with the 0.2 limit of pH change in the California Ocean Plan. A greater maximum deviation is allowed in fresh waters which characteristically exhibit greater pH variation than well-buffered estuarine or marine waters. This increase in pH variation is not considered harmful within the overall limits specified.

* <u>Dissolved Oxygen</u>

For all tidal waters, the following objectives shall apply:

In the Bay downstream of Carquinez Bridge	5.0 mg/l minimum
Upstream from Carquinez Bridge	7.0 mg/l minimum

For nontidal waters, the following objectives shall apply:

Waters designated as cold water habitat	7.0 mg/l minimum
Waters designated as warm water habitat	5.0 mg/l minimum

* Areas of Special Biological Significance shall be maintained at a level of protection consistent with natural undegraded conditions uninfluenced by any controllable water quality factor. Where natural factors cause lower concentrations, controllable water quality factors shall not cause further reduction.

* All waters designated as aquatic life habitat shall be maintained at Maintenance Level B, unless otherwise designated. In addition to these limiting numerical objectives, the lower ten percentile dissolved oxygen concnetration value shall be

determined as a function of dissolved oxygen content at saturation, in accordance with Figure 4-1.

A review of recent studies of dissolved oxygen concentrations in San Francisco Bay[5,6,7] indicates that the average concentration in portions of the Bay not significantly affected by man's activities approximates 85 percent of the saturation concentration. This value appears relatively constant throughout the Bay system with minor variations; for example; day time concentrations in the area upstream of Carquinez Strait are usually higher than 85 percent due to algal activity. Applying 85 percent of the saturation concentration together with the above requirements for a minimum dissolved oxygen concentration of not less than 5.0 mg/l, results in acceptable concentrations for various levels of maintenance as shown in Figure 4-1. In application, temperature and chloride concentration are determined at the location where the dissolved oxygen sample is obtained. These measurements permit determination of the saturation concentrations from Table 4-3; the lower 10 percentile dissolved oxygen concentration value is then found using Figure 4-1.

The dissolved oxygen objective departs from the Interim Plan statement for fresh waters and enclosed bays in wording but not in philosophy; the above wording is more closely tied to the natural habitat recognizing the resilience inherent in established aquatic life populations and the need for more strict control as natural oxygen values approach minimum values for aquatic life sustenance and propagation. The specific case of the California Ocean Plan is also relevant here, for this plan specifies that dissolved oxygen shall not be depressed more than 10 percent from that which occurs naturally. Thus the concept embodied in the objective is consistent with the ocean plan approach with the exception of the percent deviation which varies with protection levels and ambient DO concentration.

* Bacteria

In tidal waters designated for contact recreation (REC-1), the total coliform concentration, based on a minimum of not less than five consecutive samples, shall not exceed a median value of 240/100 ml, nor shall any sample exceed a total coliform concentration of 10,000/100 ml. In addition, the fecal coliform concentration, based on a minimum of five consecutive samples, shall not exceed a median value of 50/100 ml, nor shall any sample exceed a maximum fecal coliform concentration of 400/100 ml.

At all areas where shellfish may be harvested for human consumption (SHELL), the median total coliform concentration throughout the water column for any 30-day period shall not exceed 70/100 ml nor shall more than 10 percent of the samples collected during any 30-day period exceed 230/100 ml for a five-tube decimal dilution test or 33-/100 ml when a three-tube decimal dilution test is used.

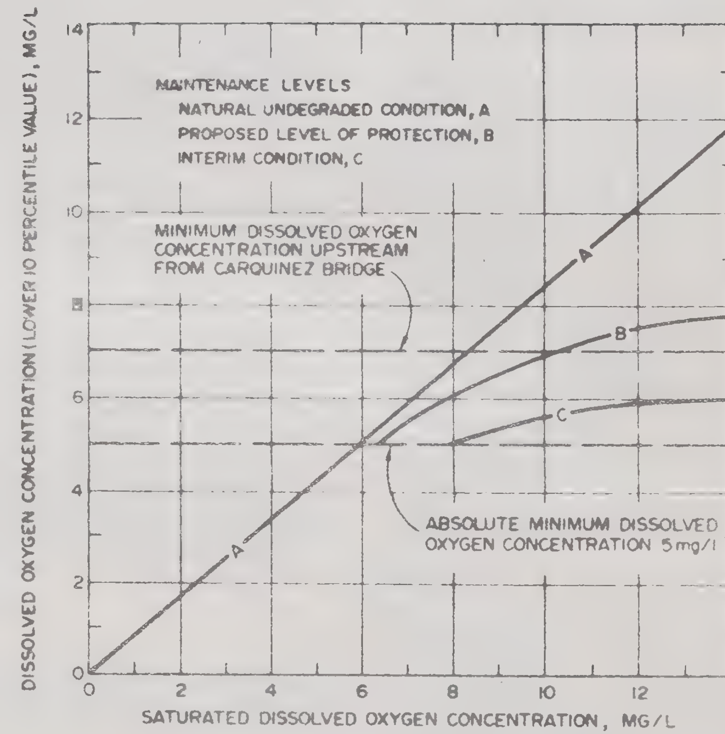
In nontidal waters designated for contact recreation (REC 1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200/100 ml, nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

/ In nontidal waters designated for noncontact recreation (REC-2) and not designated for contact recreation (REC-1), the average fecal coliform concentration for any 30-day period, shall not exceed 2,000/100 ml nor shall more than 10 percent of samples collected during any 30-day period exceed 4,000/100 ml.

In nontidal waters used for domestic drinking water supply (MUN), the arithmetic average of at least five (5) samples collected over a thirty (30) day interval shall not exceed a total coliform concentration of 100 per 100 ml or a fecal coliform of 20 per 100 ml.

Temperature

Temperature objectives for *Enclosed Bays and Estuaries* are as specified in the "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays of California" including any revisions thereto. A copy of this plan is included verbatim in the "Plans and Policies Appendix".



Lower Ten Percentile Dissolved Oxygen Concentrations

Solubility of Oxygen in Water

Temperature, °C	Chloride concentration in water, mg/l					Difference per 100 mg chloride
	0	5,000	10,000	15,000	20,000	
	Dissolved oxygen, mg/l					
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
[illegible]	8.4	8.0	7.6	7.2	6.7	0.008
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
[illegible]	7.9	7.5	7.1	6.8	6.4	0.008
[illegible]	7.8	7.4	7.0	6.6	6.3	0.008
[illegible]	7.6	7.3	6.9	6.5	6.1	0.008

In addition, the following temperature objectives apply to surface waters:

> The natural receiving water temperature of inland surface waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Board that such alteration in temperature does not adversely affect beneficial uses.
>
> At no time or place shall the temperature of any COLD water be increased by more than 5°F above natural receiving water temperature.
>
> At no time or place shall the temperature of WARM waters be increased more than 5°F above natural receiving water temperature.

✱ Toxicity

All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration or other appropriate methods as specified by the Regional Board.

The survival of aquatic life in surface waters subjected to a waste discharge or other controllable water quality factors, shall not be less than that for the same water body in areas unaffected by the waste discharge or, when necessary, for other control water that is consistent with the requirements for "experimental water" as described in *Standard Methods for the Examination of Water and Wastewater*, latest edition. As a minimum, compliance with this objective as stated in the previous sentence shall be evaluated with a 96-hour bioassay.

In addition, effluent limits based upon acute bioassays of effluents will be prescribed where appropriate, additional numerical receiving water objectives for specific toxicants will be established as sufficient data become available, and source control of toxic substances will be encouraged.

✱ Ammonia

The discharge of wastes shall not cause receiving waters to contain concentrations of un-ionized ammonia in excess of the following limits:

0.025 mg/l as N	Annual Median
0.4 mg/l as N	Maximum

✱ Pesticides

No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no increase in pesticide concentrations found in bottom sediments or aquatic life.

Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of pesticides in excess of the limiting concentrations set forth in California Administrative Code, Title 17, Chapter 5, Subchapter 1, Group 1, Article 4, Section 7019, Table 4, and listed below:

Pesticides:	mg/l
Aldrin	0.017
Chlordane	0.003
DDT	0.042
Bioldrin	0.017
Endrin	0.001
Heptachlor	0.018
Heptachlor epoxide	0.018
Lindane	0.056
Methoxychlor	1.0
Organophosphorous and Carbamate compounds (As parathion in cholinesterase inhibition)	0.1
Toxaphene	0.005

Herbicides:	mg/l
2, 4-D plus 2, 4, 5-T plus 2, 4, 5-TP	0.1

Total identifiable chlorinated hydrocarbon pesticides shall not be present at concentrations detectable within the accuracy of analytical methods prescribed in *Standard Methods for the Examination of Water and Wastewater*, latest edition, or other equivalent methods approved by the Executive Officer

Sulfide

All waters shall be free from dissolved sulfide concentrations above natural background levels.

Sulfide occurs in Bay muds as a result of bacterial action on organic matter under an anaerobic environment. Concentrations of only a few hundredths of a milligram per liter can cause a noticeable odor. Other than its consistency with the State's policy of nondegradation, the importance of this objective as stated is that deviations from natural background conditions will be minimized along with the prevalent odor associated with rotten eggs once characteristic in areas contiguous with San Francisco Bay.

* Chemical Constitutents

Water designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemcial constituents in excess of the limits specified in California Administrative Code Title 17, Chapter 5, Subchapter 1, Group 1, Article 4, Section 7019, Tables 2, 3, and 4 and listed below.

Inorganic Chemicals

Constituent	Limiting Concentration, mg/l
Arsenic	0.10
Barium	1.0
Cadmium	0.01
Chromium	0.05
Cyanide	0.2
Lead	0.05
Mercury	0.005
Nitrate-N + Nitrite-N	10
Selenium	0.01

Fluoride Concentration

Annual Average of Maximum Daily Air Temperature*	Fluoride Concentration, mg/l		
	Lower	Optimum	Upper
50-54	0.9	1.2	1.7
55-58	0.8	1.1	1.5
58-64	0.8	1.0	1.3
65-71	0.7	0.9	1.2
72-79	0.7	0.8	1.0
80-81	0.6	0.7	0.8

*Based on temperature data obtained for a minimum of five years

Organic Chemicals

Constituent	Limiting Concentration mg/l
Carbon-alcohol extract (CAE-m)	3.0
Carbon-chloroform extract (CCE-m)	0.7
Foaming agent (MBAS)	0.5

Waters designated for use as agricultural supply (AGR) shall not contain concentrations of chemical constituents in amounts that adversely affect such beneficial use.

A mean daily chloride concentration of 4,000 mg/l or less shall be maintained in waters east of the Westerly end of Chipps Island.

A mean monthly salinity at high tide of 18,000 mg/l TDS or less shall be maintained in the waters surrounding and adjacent to Suisun Marsh.

The quantity and quality of water in the bays and intertidal sloughs of Suisun Marsh shall be sufficient to produce an average salinity of 8,000 mg/l TDS in the first 12 inches of soil between April 15 and June 1 of each year.

Radioactivity

Radionuclides shall not be present in concentrations that are deleterious to human, plant, animal, or aquatic life nor that result in the accumulation of radionuclides in the food web to an extent that presents a hazard to human, plant, animal, or aquatic life.

Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of radionuclides in excess of the limits specified in California Administrative Code, Title 17, Chapter 5, Subchapter 1, Group 1, Article 4, Section 7019, Table 5, and listed below:

Radioactivity

Gross Beta	1,000 pc/l
Radium-226	3pc/l
Strontium-90	10 pc/l

Water Quality Objectives for Specific Inland Surface Waters

* Alameda Creek Watershed

The following chemical quality limits shall be maintained in the surface waters of the Alameda Creek watershed above Niles:

TDS:	250 mg/l 90 day-arithmetic mean
	360 mg/l 90 day-90th percentile
	500 mg/l daily maximum
Chlorides:	60 mg/l 90 day-arithmetic mean
	100 mg/l 90 day-90th percentile
	250 mg/l daily maximum

Whenever natural factors cause the above limits to be exceeded, then, subject to the exception below, controllable water quality factors shall not cause further degradation.

Wastewater discharges that cause the above surface water limits to be exceeded may be allowed if part of an overall water-wastewater resource operational program developed by those agencies affected and approved by the Regional Board. Approval of the program by the Regional Board will be based upon a satisfactory demonstration that the discharge will not impair the beneficial uses of the surface and/or groundwaters.

Other Inland Surface Waters

As part of the State's continuing planning process, data will be collected and numerical water quality objectives will be developed for those mineral and nutrient constituents where sufficient information is presently not available for the establishment of such objectives.

Objectives for Groundwaters

The following objectives apply to all groundwaters of the Basin.

Tastes and Odors

Groundwaters shall not contain taste or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses.

Bacteria

In groundwaters used for domestic or municipal supply (MUN) the median concentration of coliform organisms over any seven-day period shall be less than 2.2/100 ml.

Chemical Constituents

Groundwaters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the limits specified in California Administrative Code Title 17, Chapter 5, Subchapter 1, Group 1, Article 4, Section 7019, Tables 2, 3, and 4.

Groundwaters designated for use as agricultural supply (AGR) shall not contain concentrations of chemical constituents in amounts that adversely affect such beneficial use.

Radioactivity

Groundwaters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of radionuclides in excess of the limits specified in California Administrative Code, Title 17, Chapter 5, Subchapter 1, Group 1, Article 4, Section 7019, Table 5.

Specific Groundwaters

As part of the State's continuing planning process, data will be collected and numerical water quality objectives will be developed for those mineral constituents where sufficient information is presently not available for the establishment of such objectives.

Existing and Potential Beneficial Uses of Surface Waters *

	SURFACE WATERS	MUN	AGR	IND	PROC	GWR	FRSH	NAV	POW	REC 1	REC 2	COMM	WARM	COLD	ASBS	SAL	WILD	RARF	MAR	MIGR	SPWN	SHELL
1	Merced Lake	○									●			●			●					
2	Crystal Springs Lakes	●									●		●	●	○		●	●				
3	San Mateo Creek						●			○	○			○			●	●				
4	Pilarcitos Lake	●									○			●	○		●	●				
5	Pilarcitos Creek	●	●							○	○			●			●	●		●	●	
6	San Andreas Lake	●									●		●	●	○		●	●				
7	San Vicente Creek		●							○	○			●			●	●		●	●	
8	Denniston Creek		●							●	●		●	●			●	●		●	●	
9	Frenchmans Creek		●							●	●			●			●	●		●	●	
10	Purisima Creek		●							●	●			●			●	●		●	●	
11	Lobitas Creek		●							●	●			●	○		●	●		●	●	
12	Tunitas Creek		●							○	○			●	○		●	●		●	●	
13	San Gregorio Creek		●							●	●		●	●			●	●		●	●	
14	Pescadero Creek		●							●	●			●	○		●	●		●	●	
15	Searsville Lake		●							●	●		●	●			●					
16	Felt Lake		●							●	●		●				●					
17	San Francisquito Creek									○	○		●	●			●			●	●	
18	Stevens Creek Reservoir	●				●					●		●	●			●			●	●	
19	Stevens Creek						●			●	●		●	●			●			●	○	
20	Calero Reservoir	●				●				●	●		●				●					
21	Almaden Reservoir	●				●				●	●		●				●					
22	Guadalupe Reservoir	●				●				○	○		●				●					
23	Lake Elsman	●									○			●			●					
24	Campbell Percolation Ponds					●							●	●			●					
25	Lexington Reservoir	●								●	●		●	●			●					
26	Vasona Reservoir					●				●	●		●	●			●					
27	Cotton Wood Lake									●	●		●	●			●					
28	Los Gatos Creek	●				●	●				○			●			●			○	○	
29	Sandy Wool Lake										●		●	●			●					
30	Guadalupe River									○	●		●				●			○	○	
31	San Felipe Creek									○	○		●	○			●					
32	Coyote Reservoir	●	●							○	○		●	●			●					
33	Anderson Reservoir	●				●				●	●		●	●			●					
34	Cherry Flat Reservoir	●	●							○	○		●				●				●	
35	Coyote Creek									○	●		●	●			●	●		●	●	
36	Arroyo De La Laguna[1]					●				●	●		○	○			●			●	●	
37	Shadow Cliffs Reservoir									●	●		●	●			●					
38	Arroyo Del Valle[1]	●				●				○	○			●			●			○		
39	Del Valle Reservoir	●								●	●		●	●			●					
40	Alameda Creek		●			●				●	●		●	●			●			○	○	
41	Elizabeth Lake										●		●	●			●					
42	Arroyo Hondo[1]	●					●			●	●		●	●			●				●	
43	Calaveras Reservoir	●									○		●	○			●					
44	San Antonio Reservoir	●									○		●	●			●					
45	Cull Canyon Reservoir									●	●		●	○			●					
46	San Lorenzo Creek[1]									●	●		●	●			●			●	●	
47	San Leandro Reservoir	●									○		●	●			●					
48	Lake Chabot	●									●		●	●			●					
49	San Leandro Creek						●			○	○		○	●			●			○	○	
50	Lake Temescal									●	●		●				●					
51	Lake Merritt									●	●		●	●			●					
52	Briones Reservoir	●								○	○		●	○			●					
53	San Pablo Reservoir	●								●	●		●	●			●					
54	Lafayette Reservoir	●								●	●		●	●			●					
55	Pinole Creek									○	○		●	●			●			●	●	
56	Walnut Creek[1]									○	○		●	●			●					
57	Mallard Reservoir[2]	●	●	●	●						○		●				●					
58	Marsh Creek									○	○		●				●	●				
59	Marsh Creek Reservoir									○	○		●				●	●				
60	Contra Loma Reservoir[2]	●	●	●	●						●		●	●			●					
61	Lake Curry	●									○		●				●					
62	Lake Madigan	●	●								●		●	●			●					

* From State Water Resources Control Board, 1975, Water Quality Control Plan San Francisco Bay Basin (2), Part 1

Existing and potential Beneficial Uses of Surface Waters (continued)

	SURFACE WATERS	MUN	AGR	IND	PROC	GWR	FRSH	NAV	POW	REC 1	REC 2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL
63	Lake Frey	●									●		●				●					
64	Suisun Creek									○	○		●	●	○		●			●	●	
65	Suisun Slough									●	●		●		○		●					
66	Montezuma Slough									●	●		●		○		●	●				
67	Lake Herman	●									○		●	●			●					
68	Chiles Creek	●					●			○	○		●	●			●					
69	Sage Creek	●					●			○	○		●	●			●					
70	Lake Hennessey	●									●		●	●			●				●	
71	Conn Creek	●					●			●	●			●			●			●	●	
72	Rector Reservoir	●									●		●	●			●					
73	Milliken Reservoir	●									○		●				●					
74	Lake Marie	●	●							○	○		○				●					
75	Lake Chabot	●	●							●	●		●	●			●					
76	Dry Creek	●	●							●	●			●	○		●			●	●	
77	York Creek									○	○			●			●			●	●	
78	Napa River	●	●					●		●	●		●	●	○		●	●		●	●	
79	Sonoma Creek									●	●		●	●	○		●	●		●	●	
80	Petaluma River							●		●	●		●	●	○		●	●		●	●	
81	San Antonio Creek									○	○		●	●	○		●			○	○	
82	Stafford Lake	●									●		●	○			●					
83	Novato Creek	●								○	○		○	○			●			○	○	
84	Rodeo Lagoon									●	●			●			●					
85	Miller Creek									○	○		●	●			●	●		○	○	
86	Lake Lagunitas	●									●		●	●			●					
87	Bon Tempe Lake	●									●		●	●			●					
88	Alpine Lake	●									●		●	●			●					
89	Kent Lake	●									●		●	●			●					
90	Lagunitas Creek									●	●			●	○		●	●		●	●	
91	Phoenix Lake	●									○		●	●			●					
92	Nicasio Creek	●					●			●	●			●			●			●	●	
93	Nicasio Reservoir	●					●				○		●				●					
94	Olema Creek									●	●			●			●			●	●	
95	Walker Creek									○	○			●	○		●	●		●	●	
96	Crystal Lake									○	○		●				●					
97	Pacific Ocean			●				●		●	●	●			●		●	●	●	●	●	●
98	South Bay			●				●		●	●	●			●		●	●	●	●	○	●
99	Lower Bay			●				●		●	●	●			○		●	●	●	●	○	●
100	Central Bay			●	●			●		●	●	●			○		●	●	●	●	●	●
101	San Pablo Bay			●				●		●	●	●			○		●	●	●	●	●	●
102	Suisun Bay & Lower San Joaquin			●	●			●		●	●	●			○		●	●	●	●	●	
103	Delta			●	●			●		●	●	●	●		○		●	●		●	●	
104	Bolinas Lagoon									●	●	●			●		●	●	●	●	●	●
105	Drakes Estero									●	●	●			●		●	●	●		●	●
106	Limantour Estero									●	●	●			●		●	●	●		●	●
107	Tomales Bay									●	●	●			●		●	●	●	●	●	●
108	San Pedro Creek										●		●	●			●			●	●	
109	Pomponio Creek		●							○	●			●			●			●	●	
110	Corte Madera Creek									○	●			●			●	●				
111	Old Mill Creek										●			●			●					
112	Pine Gulch Creek	●									●			●			●			●	●	
113	Kimball Reservoir	●									○		●				●					

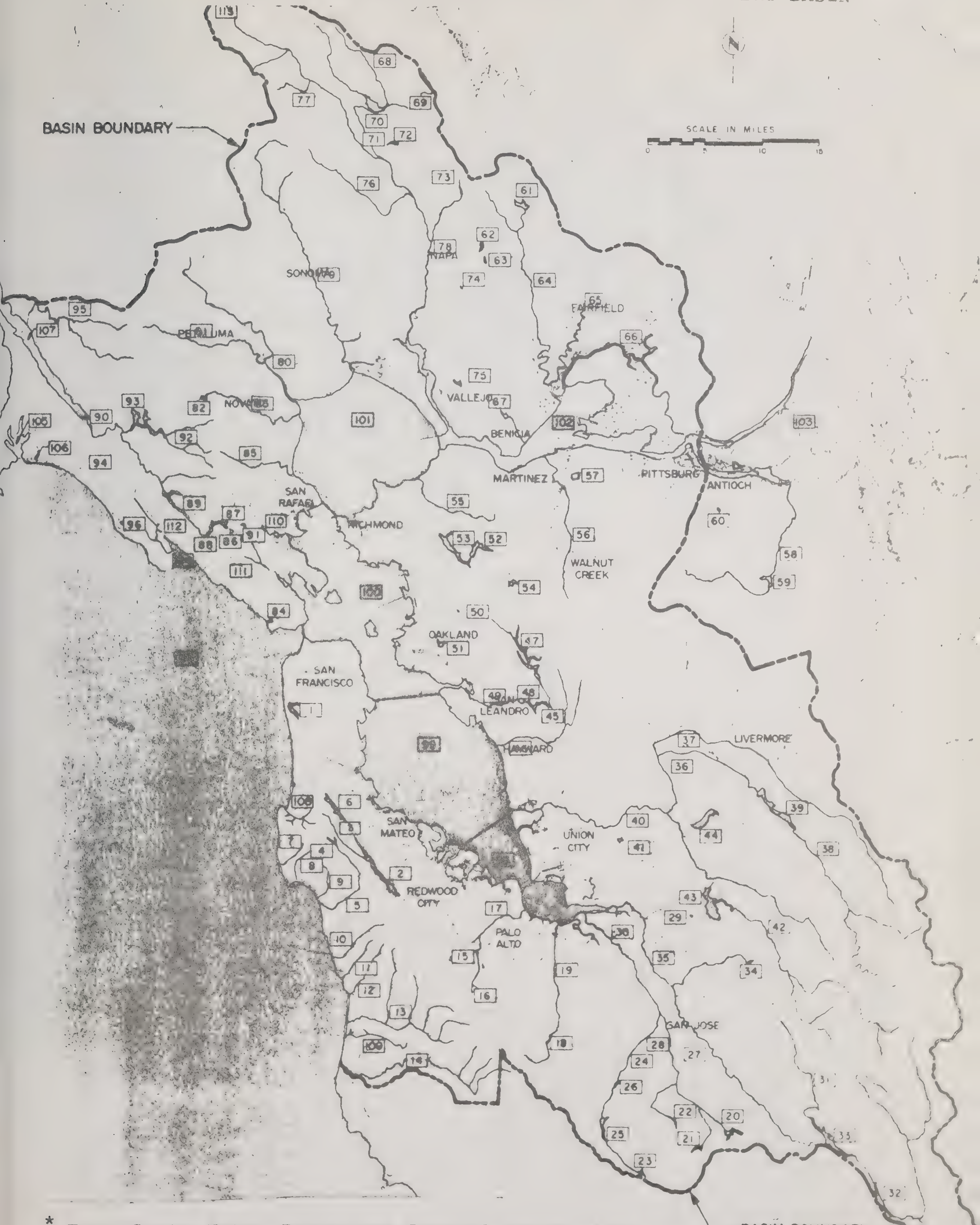
NOTES:

1. Includes Upstream Tributaries.
2. Offstream Reservoir

○ Potential Beneficial Use.

● Existing Beneficial Use.

PRINCIPAL SURFACE WATERS OF SAN FRANCISCO BAY BASIN



* From State Water Resources Control Boars, 1975, Water Quality Control Plan San Francisco Bav Basin (2), Part 1

PRINCIPLES FOR MANAGEMENT OF WATER QUALITY IN ENCLOSED BAYS AND ESTUARIES

A. It is the policy of the State Board that the discharge of municipal wastewaters and industrial process waters[2] (exclusive of cooling water discharges) to enclosed bays and estuaries, other than the San Francisco Bay-Delta system, shall be phased out at the earliest practicable date. Exceptions to this provision may be granted by a Regional Board only when the Regional Board finds that the wastewater in question would consistently be treated and discharged in such a manner that it would enhance the quality of receiving waters above that which would occur in the absence of the discharge.[3]

B. With regard to the waters of the San Francisco Bay-Delta system, the State Board finds and directs as follows:

1a. There is a considerable body of scientific evidence and opinion which suggests the existence of biological degradation due to long-term exposure to toxicants which have been discharged to the San Francisco Bay-Delta system. Therefore, implementation of a program which controls toxic effects through a combination of source control for toxic materials, upgraded wastewater treatment, and improved dilution of wastewaters, shall proceed as rapidly as is practicable with the objective of providing full protection to the biota and the beneficial uses of Bay-Delta waters in a cost-effective manner.

1b. A comprehensive understanding of the biological effects of wastewater discharge on San Francisco Bay, as a whole, must await the results of further scientific study. There is, however, sufficient evidence at this time to indicate that the continuation of wastewater discharges to the southern reach of San Francisco Bay, south of the Dumbarton Bridge, is an unacceptable condition. The State Board and the San Francisco Regional Board shall take such action as is necessary to assure the elimination of wastewater discharges to waters of the San Francisco Bay, south of Dumbarton Bridge, at the earliest practicable date.

1c. In order to prevent excessive investment which would unduly impact the limited funds available to California for construction of publicly owned treatment works, construction of such works shall proceed in a staged fashion, and each stage shall be fully evaluated by the State and Regional Boards to determine the necessity for additional expenditures. Monitoring requirements shall be established to evaluate any effects on water quality, particularly changes in species diversity and abundance, which may result from the operation of each stage of planned facilities

and source control programs. Such a staged construction program, in combination with an increased monitoring effort, will result in the most cost-effective and rapid progress toward a goal of maintaining and enhancing water quality in the San Francisco Bay-Delta system.

2. Where a waste discharger has an alternative of in-bay or ocean disposal and where both alternatives offer a similar degree of environmental and public health protection, prime consideration shall be given to the alternative which offers the greater degree of flexibility for the implementation of economically feasible wastewater reclamation options.

The following policies apply to all of California's enclosed bays and estuaries:

1. Persistent or cumulative toxic substances shall be removed from the waste to the maximum extent practicable through source control or adequate treatment prior to discharge.
2. Bay or estuarine outfall and diffuser systems shall be designed to achieve the most rapid initial dilution[4/] practicable to minimize concentrations of substances not removed by source control or treatment.
3. Wastes shall not be discharged into or adjacent to areas where the protection of beneficial uses requires spatial separation from waste fields.
4. Waste discharges shall not cause a blockage of zones of passage required for the migration of anadromous fish.
5. Nonpoint sources of pollutants shall be controlled to the maximum practicable extent.

The official statewide definitions of beneficial uses are as follows:

Municipal and Domestic Supply (MUN) — Includes usual uses in community or military water systems and domestic uses from individual water systems.

Agricultural Supply (AGR) — Includes crops, orchard and pasture irrigation, stock watering, support of vegetation for range grazing and all uses in support of farming and ranching operations.

Industrial Process Supply (PROC) — Includes process water supply and all uses related to the manufacturing of products.

Industrial Service Supply (IND) — Includes uses that do not depend primarily on water quality such as mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.

Groundwater Recharge (GWR) — Natural or artificial recharge for future extraction for beneficial uses and to maintain salt balance or halt salt water intrusion into freshwater aquifers.

Freshwater Replenishment (FRSH) — Provides a source of freshwater for replenishment of inland lakes and streams of varying salinities.

Navigation (NAV) — Includes commercial and naval shipping.

Hydropower Generation (POW) — Used for hydropower generation.

Water Contact Recreation (REC-1) — Includes all recreational uses involving actual body contact with water, such as swimming, wading, water skiing, skin diving, surfing, sport fishing, uses in therapeutic spas, and other uses where ingestion of water is reasonably possible.

Non-Contact Water Recreation (REC-2) — recreational uses that involve the presence of water but do not require contact with water, such as picnicking, sunbathing, hiking, beachcombing, camping, pleasure boating, tidepool and marine life study, hunting and aesthetic enjoyment in conjunction with the above activities as well as sightseeing.

Ocean Commercial and Sport Fishing (COMM) — The commercial collection of various types of fish and shellfish, including those taken for bait purposes, and sport fishing in oceans, bays, estuaries and similar nonfreshwater areas.

Warm Freshwater Habitat (WARM) — Provides a warm water habitat to sustain aquatic resources associated with a warm water environment.

Cold Freshwater Habitat (COLD) — Provides a cold water habitat to sustain aquatic resources associated with a cold water environment.

Preservation of Areas of Special Biological Significance (ASBS) — Areas of special biological significance are those areas designated by the State Water Resources Control Board as requiring protection of species or biological communities to the extent that alteration of natural water quality does not occur.

Saline Water Habitat (SAL) — Provides an inland saline water habitat for aquatic life resources. Soda Lake in the Central Coastal Basin is a saline habitat typical of desert lakes in inland sinks.

Wildlife Habitat (WILD) — Provides a water supply and vegetative habitat for the maintenance of wildlife.

Preservation of Rare and Endangered Species (RARE) — Provides an aquatic habitat necessary, at least in part, for the survival of certain species established as being rare and endangered species.

Marine Habitat (MAR) — Provides for the preservation of the marine ecosystem including the propagation and sustenance of fish, shellfish, marine mammals, waterfowl and vegetation such as kelp.

Fish Migration (MIGR) — Provides a migration route and temporary aquatic environment for anadromous or other fish species.

Fish Spawning (SPWN) — Provides a high quality aquatic habitat especially suitable for fish spawning.

Shellfish Harvesting (SHELL) — The collection of shellfish such as clams, oysters, abalone, shrimp, crab and lobster for either commercial or sport purposes.

APPENDIX B

CANDIDATE SURFACE RUNOFF CONTROL MEASURES

Group A - Measures to reduce accumulation of pollutants prior to runoff.

These control measures are primarily designed for the reduction of pollutant accumulation in streets, storm drains, channels, etc. prior to the occurrence of storm.

1. Provide more frequent street cleaning

   Increase in the frequency of street cleaning in densely populated or commercial areas.

2. Provide more efficent methods of street cleaning

   Use of more efficent street cleaning devices or methods to reduce the amount of solid particles in the street.

3. Repair streets

   Repair of streets in order to increase street cleaning efficency and to reduce the accumulation of pollutants.

4. Control certain chemicals

   Control use of certain chemicals which are known sources of pollutants. Such products include lawn fertilizers, pesticides, and other toxic chemicals used by householders.

5. Restrict auto parking

   Restriction of auto parking in order to increase street sweeping effectiveness.

6. Control use of lots and streets

   Reduction in the type of activities such as painting and car washing, auto repair and maintenance.

7. Control dumping

   Control of dumping of residential, commercial, and industrial wastes on lots and streets.

8. Control littering and dog droppings

   Control littering and dog droppings on streets and gutters.

9. Control automobile and other emissions

   Control of emission from mobile and stationary air pollution sources, in order to lessen the amount of fallout which contribute to runoff pollutants. (This control measure will be considered by ABAG and not by the local agencies.)

10. Control direct discharge of pollutants

    Control of direct discharge to storm water collection systems of pollutants such as paint, motor oil, pesticides, chemicals, and other hazardous liquid and solid wastes.

11. Clean storm water collection system

    Periodic flushing and cleaning of storm drains and removal of debris from channels, pipes, inlets to prevent accumulation of solids in the collection system, perhaps keyed to prediction of rain.

12. Replace cross connections of sewerage systems

Separation of any cross connections between the storm sewer system and sanitary sewer system.

13. Insure proper operation of septic tanks and leach fields.

Proper construction and maintenance of septic tanks and leach fields to prevent surfacing sentic tank effluents, which would increase the BOD and bacteria loading of surface runoff.

Group B - Measures to control land use

These control measures are primarily land use requirements which would modify the amount of pollutants and runoff generated from developed areas.

1. Develop slope density standards

   Establishment of slope density standards which would limit the development of hillside areas thereby reducing the amount of sediments and runoff.

2. Maintain open space areas

   Concentration of urban development to minimize the impervious land surface which will increase the quantity of runoff.

3. Control development patterns

   Control of certain types of land use which are known to cause high amount of pollutants or runoff in environmentally sensitive areas. For example, restriction of development in flood plain or near stream channels and lakes in order to prevent large amount of pollutants from being transported directly into the waterway.

4. Develop buffer strip requirements

   Development of buffer strip such as grass lands or undeveloped open space surrounding new developments in order to reduce the amount of runoff by infiltrating or retarding storm water.

Group C - Measures to reduce amount of pollutants and the peak flow or volume of runoff.

These control measures are primarily designed to reduce the total amount of pollutants and the peak flow or volume of runoff. It should be noted that modification of the peak flow alone may or may not reduce the amount of runoff or pollutants.

1. Control roof drains

   Control of roof drains connected to storm sewers in order to reduce amount of runoff.

2. Construct rooftop detention and storage

   Construction of rooftop detention and storage with appropriate outlet structures in order to delay the runoff thereby reducing the peak of the hydrograph.

3. Rechannel runoff to prevent flow over critical surfaces

   Construction of channels, berms and other control structures to reroute flows around areas that have accumulated pollutants.

4. Redesign curb and gutter configurations

   Redesign of curbs and gutters and streets to either delay or speed up the flow of urban runoff to provide for a more uniform flow in the collection system.

5. Remove debris in channels, pipes, and inlets, to improve flow.

   Removal of large size debris such as construction and demolition debris in order to improve flow conditions in the collection system thereby reducing overflow; flooding and erosion.

6. Regrade disturbed areas

   Regrading or terracing of areas that have been modified by construction related events or by natural erosion, in order to reduce the amount of sediment carried off by runoff.

7. Reseed or apply vegetative cover to bare slopes

   Reseeding or applying vegetative cover to bare slopes to prevent loss of top soil thereby reducing the amount of sediments carried off by runoff.

8. Stabilize channels of rivers and streams

   Stabilizing channels of rivers and streams to prevent soil loss in the storm channel through erosion and undercutting.

9. Control erosion at construction sites

   Control of erosion at construction sites by checkdams, berms, straw bales, mulch and road maintenance in order to reduce or prevent runoff from reaching major drainage channels by entrapping sediment that has been carried off the construction site.

10. Regulate construction schedules to avoid concentration of activities in time or space.

    Regulation of construction schedules to insure that runoff might be minimized either by staging or by scheduling projects with a consideration of runoff impacts.

11. Construct permanent berms for critical sources

    Construction of permanent berms for critical sources such as gas stations, garages, and feedlots to prevent

runoff carrying critical constituents (metals, hydrocarbons, oil and greases) from reaching the stormwater collection system.

12. Use energy dissipators to reduce potential for erosion or transport of solids.

    Construction of dissipators in stream channels to reduce sediment load and prevent channel erosion.

13. Increase perviousness of surfaces

    Increase of pervious surfaces through construction of Dutch drains or porous asphalt paving in flat areas to allow water to infiltrate into the ground in order to reduce runoff.

14. Require minimum amount of pervious surfaces for new construction.

    Requiring new construction projects to maintain a certain percent of the land to be pervious.

15. Use efficent tillage and plowing practices for agricultural areas.

    Use of efficent tillage and plowing practices for agricultural areas to minimize areas disturbed thereby reducing runoff and soil erosion.

16. Modify drainage basin

    Modification of land drainage to reduce the flow and to change the routing of runoff.

Group D - Measures to treat and store runoff

These measures are primarily designed to treat runoff directly or store flows for later treatment. They are mostly high capital intensive structural solutions. It should be emphasized that these measures will only be considered at a reconnaissance level in preparing the county surface runoff management plan. Reconnaissance level means that the investigation would be limited to the following:

- A brief description of the control measure including the type of proposed facilities and treatment process and the capacity and method of operation of the facilities.
- A map of the county showing the location of major proposed facilities.
- An estimation of capital and operation and maintenance costs based on cost curves provided by ABAG.

1. Trap sediment and solids by use of catch basins

   Construction of large catch basins to trap sediments carried by the storm water.

2. Impound runoff in upstream channels

   Upstream impoundment of runoff to modify the peak flow.

3. Construct on-line or off-line storage

   Construction of aboveground or underground storage facilities including ponds and tanks and oversized interceptors to which the storm water flow can be diverted and released after the peak storm flow.

4. Use existing capacity of storm sewers for storage of flows.

   Use existing capcity of storm sewers for storage of flow. It may require use of remote sensing and computer-directed control systems that provide centralized control of regulator and pumping stations on trunk and interceptor sewers to optimize storage.

5. Construct treatment facilities

   Construction of treatment unit processes such as screening, floatables removal, filtration disinfection, nutrient removal, swirl concentrators, biological systems, and physical-chemical systems depending on the type and amount of pollutants to be removed. Such unit processes can be added to the existing facilities or constructed as new facilities for storm water.

6. Use capacity at existing treatment plants

   Use of available capacity at existing treatment plants to remove pollutants from storm water. Such a measure would require flow equalization and storage.

7. Prevent direct discharge of storm water into receiving waters.

   Prevention of direct discharge of storm water into receiving waters by routing of treated or untreated storm waters to artificial lakes, or irrigation ponds.

SURFACE RUNOFF MANAGEMENT PROGRAM

LIST OF HANDOUT MATERIALS

FEBRUARY 9, 1977

TECHNICAL MEMORANDA

1. "Preliminary Outline of Storm Water Sampling Program," Technical Memorandum No. 1, ABAG Staff. 12 pp.

2. "Procedure for Review and Update of Base Maps" and "Drainage Areas of Streams Tributary to San Francisco Bay," Technical Memorandum No.2, ABAG Staff. 13 pp.

3. "Demonstration Watersheds Description and Selection Criteria," Technical Memorandum No.3, ABAG Staff. 6 pp.

4. "County Water Quality Sampling Programs Modifications and Comments," Technical Memorandum No.4, ABAG Staff. 15 pp.

ISSUE PAPERS

5. "Organizational structure of the Surface Runoff Management Program," Issue Paper No.1 ABAG Staff. 30 pp.

PROGRESS REPORTS

6. "Summary of County Water Quality Sampling Programs," Progress Report No.1, ABAG Staff. 59 pp.

HANDOUT MATERIALS LISTED BY WORKSHOPS

Workshop #1 - Introduction to Surface Runoff Modeling (Sept. 15, 1976)

7. Workshop #1 Agenda, ABAG Staff. 1 p.

8. "Planning a Study Using Stormwater Management Models," Gerald T. Orlob, Resource Management Associates. 12 pp.

9. "Technical Approach Overview," John A. Lager, Metcalf & Eddy, Inc. 5 pp.

10. "Introduction to the Macroscopic Planning Model (MAC)," George B. Otte, Metcalf & Eddy, Inc. 17 pp.

11. Questionnaire, "Surface Runoff Water Quality Analysis," Staff, Metcalf & Eddy, Inc. 7 pp.

12. "Proposed Application of the Macroscopic Planning Model (MAC)," William G. Smith, Metcalf & Eddy, Inc. 5 pp.

13. "Macroscopic Planning Model (MAC) Example Problem," George B. Otte, Metcalf & Eddy, Inc. 10 pp.

14. "Site Specific Model Description," William R. Norton, Resource Management Associates. 15 pp.

15. "Application to ABAG-208 Surface Runoff Project," Dennis McLaughlin, Resource Management Associates. 11 pp.

16. Example of SWMM Model Application, William R. Norton, Resource Management Associates. 20 pp.

17. "Interfacing of Models and Problem Solving," Robert M. Finn, Metcalf & Eddy, Inc. 9 pp.

18. "Surface Runoff Consultant-County Liaison," M&E, RMA Staffs. 1 p.

19. "Surface Runoff Management Program - County Work Schedule," ABAG Staff. 1 pp.

<u>Workshop #2</u> - Monitoring Techniques & Procedures (September 30, 1976)

20. "Immediate Objectives of County Monitoring Programs," Yoram J. Litwin, ABAG. 12 pp.

21. Workshop #2 Agenda, ABAG. 1 p.

22. "Characteristics of Runoff Relating to Modeling," William R. Norton, Resource Management Associates. 13 pp.

23. "Water Quality Parameters and Analytical Procedures," Eugene Y. Leong, ABAG, 8 pp.

24. "Monitoring Handbook," Marc Sylvester and Gary L. Pederson, U.S.G.S. 24 pp.

25. "Urban Storm Runoff & Treatment Process," Marc Sylvester and Gary Pederson, USGS. 17 pp.

26. "EPA Policy on Equipment Purchase and Rental Under 208 Grants," Harry Seradarian, EPA, 1 p.

27. "Field Methods for Measurement of Fluvial Sediment," Harold P. Guy and Vernon W. Norman. Chapter C2 of "Techniques of Water-Resources Investigations of the United States Geological Survey," U.S. Dept. of the Interior. 1970.

28. "Methods for Collection and Analysis of Water Samples for Dissolved Minerals and Gases," Eugene Brown, M.W. Skougstad, and M.J. Fishman. Chapter A1 of "Techniques of Water-Resources Investigations of the United States Geological Survey," U.S. Dept. of the Interior. 1970. 160 pp.

29. "Possible Problems Encountered While Sampling - An Example of Past Survey," William G. Smith, Metcalf & Eddy, Inc. 4 pp.

30. "Sample Preservation," LFE Environmental Laboratories. 7 pp.

Workshop #3 - Field Demonstration of Monitoring Techniques (Oct. 18, 1976)

31. Workshop #3 Agenda, ABAG. 1 p.

32. "Preliminary List of Candidate Demonstration Watersheds," ABAG Staff. 1 p.

33. "Selection of Water Quality Monitoring Parameters," ABAG Staff. 1 p.

Workshop #4 - Demonstration of Modeling Results (Nov. 17, 1976)

34. "Surface Runoff Modeling Overview and Preliminary Findings MAC Planning Model," Metcalf & Eddy, Inc., 7 pp.

35. "Modeling Surface Runoff Water Quality with SWMM -- An Experience from ABAG's Sonoma Study (part I), Steve Goldman. 1 p.

36. "Surface Runoff Management Program Task Assignment and Work Status Report," ABAG. 1 p.

37. "MAC Model Output Assessment and Trial Mitigation Runs," Metcalf & Eddy, Inc., 10 pp.

38. "Setup System Software for Data Management, Task 4a," Metcalf & Eddy, Inc., 41 pp.

39. "Surface Runoff Modeling Workshop Notes Site Specific Model," Metcalf & Eddy, Inc. 29 pp.

40. "Analysis of Surface Runoff Control Measures Task 22," Metcalf & Eddy, Inc., 29 pp.

41. "MAC Model Data Preparation and Program Execution," Metcalf & Eddy, 19 pp.

42. Workshop #4 Agenda, ABAG. 1 p.

43. "Storm Water Management Model User's Manual Version II," EPA-670/2-75-017, Mar. 1975. 351 pp.

44. "Development and Application of a Simplified Stormwater Management Model," EPA-600/2-76-218, Aug. 1976. 139 pp.

45. "Short Course Proceedings Applications of Stormwater Management Models," EPA-670/2-75-065. Jun, 1975. 427 pp.

Workshop #5 - Introduction to Surface Runoff Control Measures (Dec. 15, 1976)

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59. "The Modeling Program - Status Report," Metcalf & Eddy in association with Resource Management Associates, Jan. 26, 1977. 52 pp.

60. "Example Problems for Analysis with MAC," Metcalf & Eddy in association with Resource Management Associates, Jan. 26, 1977. 2 pp.

61. "MAC Watersheds," (Map), Metcalf & Eddy, Jan. 26, 1977. 1 p.

62. "Discussion Topics RMA Session of the ABAG Modeling Workshop," Resource Management Associates Staff. Jan. 26, 1977. 2 pp.

63. "Stormwater Management Model (SWMM) - List of Handouts for York St. Example," Resource Management Associates Staff, Jan. 26, 1977. 1 p.

64. "Stormwater Management Model (SWMM) - Overall Input Data Structure," RMA Staff, Jan. 26, 1977. 1 p.

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SURFACE RUNOFF MANAGEMENT PLAN

STATUS REPORT NO. 2

POLLUTION PROBLEMS

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JUNE 22, 1977
ASSOCIATION OF BAY AREA GOVERNMENTS

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INTRODUCTION

This is the second brief on the Surface Runoff Management Plan. This brief addresses existing and future stormwater quality and makes an assessment of the total pollution loads from stormwater entering San Francisco Bay. It also examines a variety of intra-county pollution problems caused by surface runoff. The combined impact of stormwater runoff and effluent from municipal, industrial and other sources on San Francisco Bay is addressed in the brief entitled "Future Water Quality and Pollution Problems."

The information contained in this brief is based on the work carried out by the County Lead Agencies under the direction of ABAG and its consultants, Metcalf and Eddy, Inc. and Resource Management Associates. It is based on three sources:

- Surveys by counties and previous reports
- Sampling of storm runoff in the not-so-wet season of 1976-77
- Mathematical modeling of surface runoff quality and quantity.

Problems from each source are presented in three separate sections. This will make clear the source of information leading to conclusions about problems. The method of presentation is intended to respond directly to concerns about the effects of the drought on runoff and the role of mathematical models in arriving at conclusions. A short glossary of technical terms is included in Appendix E.

This brief also draws conclusions from the work completed so far and presents an action for EMTF approval.

ISSUE AND ACTION FOR EMTF APPROVAL

ISSUE: Each of the counties has completed the phase of their work dealing with identification of pollution problems caused by surface runoff. The problems they identified occur in the streams and reservoirs of the region. The problems are widespread as are their causes. In a few cases, the problems are very obvious (Lake Merritt, for example). In many cases, however, problem identification is less precise. Overall, the nature of the problem is such that pollution from surface runoff cannot now be ignored, but the current knowledge about the problem will not justify costly controls.

ACTION: A plan should be developed which will result in reductions of pollution problems caused by surface runoff in streams and reservoirs. The plan should incorporate the concept of Best Management Practices, i.e. it should emphasize the non-structural, near-term solutions to the pollution problems. The plan should be a reasonable initial step in solving the problems, it should provide for further definition of problems, and it should not be costly to implement.

MAJOR CONCLUSIONS

- A number of surface runoff pollution problems and their causes have been identified by counties (see TABLE 2). More work must be done in specifying where and when these problems occur, and what are their causes.

- The monitoring data collected this year is representative despite the drought. In general, the data compare well with records of previous years and with national data. A notable exception is rural areas, where data collection was reduced and/or biased because of low flow.

- The data indicates that surface runoff contains contaminants. In the absence of definite Federal and State standards, it is difficult to provide irrefutable documentation that surface runoff is polluted, but the collected data strongly suggest that runoff contributes to water quality problems in the Bay.

- Large quantities of pollutants are discharged into the Bay with storm-water runoff. The most significant appear to be suspended solids and heavy metals, which considerably exceed the total loads to the Bay from municipal and industrial sources.

- Examination of pollution problems over the 25-year planning period does not indicate a major increase in surface runoff pollution due to urban development. In gross terms, the existing problems are also the future problems. However, the proportion of the pollutants loads to the Bay attributable to surface runoff will increase substantially as the planned wastewater treatment facilities are built.

- Although further analysis is desirable, the work completed by the counties is sufficient for initial planning puporses. Additional examination of existing and future water quality problems should be carried out as part of the continuing planning process.

PROBLEMS IDENTIFIED BY INDIVIDUAL COUNTIES

This section draws on all aspects of county work, but is based primarily on the first set of progress reports prepared by the counties during February to April, 1977. These reports summarized the county surveys on problems and/or pollution causes related to surface runoff. The approach to county problem identification of information and scope of work are discussed below. Individual county summaries of major findings related to surface runoff pollution are provided in Appendix A.

1. The Method of Examining Existing Water Quality Problems in Each County

The control of nonpoint source pollution is a relatively new approach towards solving regional and national water pollution problems. While a considerable body of knowledge and experience exists for assessing point sources, the same is not true for nonpoint pollution. There still is a lack of knowledge about existing problems. There is also a lack of definite standards for problem definition. The task of problem identification is further complicated by the inseparable relationships between land and water.

Therefore, the goal of problem idnetification is to relate practices on land with the quality of water flowing from that land. To further this goal, a distinction is made between two categories of problems:

- problems in water
- problems on land

The bodies of water for problem identification were defined as those surface waters and their tributaries identified in the BASIN PLAN.[1] The 113 water bodies listed in the plan have known existing and potential beneficial uses. Any impairement of these beneficial uses is considered a surface runoff related problem. In addition, pollution from surface runoff cannot be described as a problem unless the magnitude of the pollutant loads is considered. For that purpose the counties made comparisons between pollution loads from point sources (i.e., municipal and industrial treatment facilities) and from nonpoint sources (i.e., surface runoff). Also, comparisons were made by contrasting nonpoint loads with nationwide data from undisturbed areas. In these instances, problem identification became less specific and more reliance was placed on subjective analysis.

A detailed subdivision of most common problems occurring in water and on land, as provided to the counties, is shown in TABLE 1. The overlap and interaction among these categories is apparent. This talbe does not represent an exhaustive

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[1]State Water Resources Control Board, "Water Quality Control Plan Report - San Francisco Bay Basin (2)," prepared for the San Francisco Bay Regional Water Quality Control Board by a consortium of three consulting engineering firms: Brown and Caldwell, Water Resources Engineers, Inc. and Yoder-Trotter-Orlob and Associates, April 1975.

TABLE 1

GUIDANCE FOR IDENTIFICATION OF SURFACE RUNOFF POLLUTION PROBLEMS

PROBLEMS IN WATER	PROBLEMS ON LAND
1. BIOLOGICAL PROBLEMS a. Algae bloom b. Excess aquatic weeds c. Fish kills d. "Rough" fish e. "Sewage" fungus	1. URBAN a. Streets containing dirt and debris b. Parking lots without infiltration facilities c. Large gardens or lawns directly bordering street or sidewalk
2. PHYSICAL PROBLEMS a. Sediment - Solids b. High water temperatures c. Oil on surface d. "unnatural" color	2. AGRICULTURE a. Tilling next to stream b. Tilling on steep slopes c. Land overgrazed d. Animals with direct access to stream (Streambank not fenced) e. Farms without waste management plans
3. CHEMICAL PROBLEMS a. Pesticides b. Heavy metals c. pH d. Radioactivity e. Low dissolved oxygen f. High nutrients g. Toxics h. Taste i. Odor	3. FORESTRY, MINING, OPEN SPACE a. Surface mining b. Landfill sites with surface runoff c. Logging operations d. Vegetation destroyed by fire
4. HEALTH AND RECREATION PROBLEMS a. Excess turbidity b. High bacterial counts	4. ROADS a. Steep road-cuts b. Unvegetated road-cuts c. Significant portion of road bordering streams d. Road surface in disrepair e. Large number of unpaved roads
	5. PROBLEMS COMMON TO ALL LAND USES a. Gully formation b. Streambank vegetation reduced or absent c. Construction sites lacking erosion control d. Streambank erosion

list of all possible problems. The purpose of this table is to indicate the kinds of problems that are typically related to surface runoff. Counties used this information to assist in problem identification rather than problem classification.

The problems on land section was intended to focus attention on land management practices which may cause significant water quality degradation. Following from the definition of problems within water, the problems on land include those small streams not addressed by the BASIN PLAN as having beneficial uses.

2. Sources of Information for County Problem Identification

Counties were given the following information sources to assist them in their work. Many of the listed governmental and private groups possess an extensive knowledge on water quality problems and sources. These sources were never previously surveyed on a county-wide basis.

- U.S. Geological Survey
- U.S. Army Corps of Engineers
- U.S. Environmental Protection Agency
- State Water Resources Control Board
- California Department of Water Resources
- Regional Water Quality Control Board - San Francisco Bay Region
- State, county and city health departments
- Resource Conservation Districts
- Mosquito Abatement Districts
- Local university biology, natural resource, public health and environmental engineering departments
- The San Francisco Bay Basin Plan
- ABAG's Base Maps

One of the major benefits of the county surveys is the resulting compilation and recognition of the various activities influencing the quality of surface runoff. The county surveys are published in the first set of county progress reports. The compiled information is a necessary step for achieving comprehensiveness of the control measure alternatives considered by each county.

3. Summary of the Most Significant Results

The problems identified by the counties are summarized in TABLE 2. The most signficant results are presented below in a question-answer format. Summaries of results for individual counties are given in Appendix A.

TABLE 2

SURFACE RUNOFF PROBLEMS OBSERVED OR REPORTED IN PREVIOUS STUDIES

PROBLEM	EFFECT	EXAMPLES[2]	COUNTIES WITH REPORTED PROBLEM[1]								CAUSE
			Mar	Son	Nap	Sol	CC	Ala	SC	SM	
EROSION	A source of silt, nutrients, & bacteria.	Cull Canyon, Ala. Co. Steep road banks in Marin Co.	X				X	X		X	Improper construction or agricultural practices. Any practice which exposes bare soil to rain & runoff or any soil to excessive runoff.
SILTATION	Makes water more turbid. Covers fish spawning beds. Generally clogs streams. Reduces reservoir capacity.	Lake Temescal, Ala. Co. Permanante & Adobe Cr., SC Co.. Channels in Pacifica.	X	X	X		X	X	X	X	Erosion & subsequent low velocity of water allowing suspended materials to settle.
PRESENCE OF GREASE, OIL, & OTHER FLOATING MATERIAL	Unsightly. Coats birds & aquatic life. Makes recreational use undesirable. Toxic to aquatic life.	Suisun Bay, Sol. Co., unnamed channel in Richmond. Streams & sloughs, Milpitas, Sunnyvale & other SC Co. cities.		X	X	X		X	X	X	Industrial activity. Traffic. Dumping of motor oil & other floating substances.
PRESENCE OF DEBRIS & LITTER	Unsightly. Makes recreational use undesirable. Can be source of other pollutants.	All tidal flats around bay. Streams in So. SC Co. Most cities in Ala Co.			X		X	X	X	X	Dumping & refuse disposal & general littering where material can be washed off.
BACTERIAL CONTAMINATION	Indicative of presence of fecal material. Contact/ingestion can cause disease. Contaminates aquatic life, especially shellfish. Eliminates recreational uses depending on level of contamination.	Suisun Bay, Sol. Co. Lake Merritt & Lake Temescal, Ala. Co. Various streams in So. SC Co. Bolinas Lagoon & Richardson Bay, Marin Co. Most shellfish beds in SM Co.	X	X	X	X		X	X	X	Deposit of fecal material in areas subject to runoff. Cross connections with sanitary sewers. Malfunctioning septic tanks.

SURFACE RUNOFF PROBLEMS OBSERVED OR REPORTED IN PREVIOUS STUDIES (continued)

PROBLEM	EFFECT	EXAMPLES(2)	COUNTIES WITH REPORTED PROBLEM(1)								CAUSE
			Mar	Son	Nap	Sol	CC	Ala	SC	SM	
SEPTIC TANK MALFUNCTIONS	A source of bacterial contamination	Edgerly Is. & Conn Ck., Napa Co. Various areas, SC Co. Emerald Lake Hills, SM Co.		X	X	X		X	X	X	Poor or infrequent maintenance. Poor design & construction. Construction in unsuitable locations.
ALGAE GROWTH	Unsightly. Can cause taste & odors in drinking water. Can result in low concentrations of dissolved oxygen. Some is good; too much is bad. Hard to control once started in relatively confined water.	Napa R; Milliken, Rector & Bell Canyon Res. & Lake Hennessey in Napa Co. Lower Sonoma Cr., Suisun & Honkers Bay, Sol. Co. Bolinas Lagoon, Marin Co. Sloughs in SC Co. Lagoons in SM Co.	X	X	X	X			X	X	Additions of nutrients, especially nitrogen & phosphorus.
FISH KILLS OR IMPAIRMENT OF FISHING	Removes an important recreational or commercial use.	Fishing not allowed in Almaden & Calero Res. & downstream creeks, SC Co. Fish kills occur in Carquinez Straight & Lake Merritt (Ala.Co.)				X		X	X	X	Low dissolved oxygen. Presence of toxic substances which taint fish.
HEAVY METAL CONTAMINATION	Toxic to aquatic life. Tendency to magnify in food chain, i.e. lower forms have relatively low concentrations in body tissue, higher forms (fish & aquatic birds) have high concentration.	Mercury in Almaden & Calero Res. & downstream creeks in SC Co. Suisun & Grizzly Bays in Sol. Co.	X			X		X	X		Traffic. Runoff from industrial areas. Runoff from refuse and garbage. Leaching of mine tailings.
LOW DISSOLVED OXYGEN	Dissolved oxygen essential to most desirable forms of aquatic life. Water is saturated with dissolved oxygen when concentration 8 or 9 mg/l. Less than 5-7 mg/l can harm some species.	Napa R., Lower Sonoma Cr., Suisun Slough in Sol. Co. Lower Petaluma R. in Son. Co., sloughs in SC Co.		X	X	X			X		Addition of organic material (eaten by bacteria in water, bacteria use dissolved oxygen in process) Organic material from soil/plant origin or from traffic or industrial activities.

SURFACE RUNOFF PROBLEMS OBSERVED OR REPORTED IN PREVIOUS STUDIES (continued)

PROBLEM	EFFECT	EXAMPLES(2)	COUNTIES WITH REPORTED PROBLEM(1) Mar	Son	Nap	Sol	CC	Ala	SC	SM	CAUSE
NUTRIENTS	Addition of Nutrients can cause algae growth if there is a shortage of nutrients in water. In the bay, generally a shortage of nitrogen & excess of phosphorus. For the bay, nitrogen can be a pollutant; phosphorus is probably not.	Reported generally in Marin, especially Richardson Bay. Petaluma R., Son. Co., South Bay & sloughs in SC Co.	X	X				X	X		From natural organic material, fertilizers, industrial runoff, traffic.
SANITARY SEWER OVERFLOWS INTO STORM RUNOFF	Introduces a variety of pollutants, especially organic material, nutrients, & toxic substances.	Sonoma Valley San. Dist. some locations in Oakland, Some locations in San Jose.		X				X	X	X	Cross connections between sewer systems
OTHERS		PBC's (organic toxicant) in Suisun Bay				X					Probably from industrial waste
		Pestidides in Suisun Slough in Sol. Co.				X					From agricultural activity
		Organic material generally in Marin Co.	X								See low dissolved oxygen above.

(1) Progress report on existing water quality problems had not been received from Contra Costa County at the time this table was prepared.
(2) Examples specifically mentioned in county reports. Lack of examples elsewhere does not indicate absence of problem.

- *WHAT SURFACE RUNOFF POLLUTION CONTAMINANTS HAVE BEEN IDENTIFIED BY COUNTY SURVEYS OR IN OTHER REPORTS?*

  Twelve types of surface runoff contaminants occur in most counties. Several other contaminants occur only in parts of the region.

  Some of the contaminants cause problems. Heavy metal contamination, for example, can cause impairments to fishing.

  More work needs to be done in some counties to determine the extent to which contaminants on land contribute to surface runoff. The potential problems on land cited in TABLE 1 have not been thoroughly addressed to this point.

- *HOW COMMON ARE THESE TWELVE CONTAMINANTS AMONG COUNTIES?*

  Most counties reported problems in siltation bacterial contamination, and algae growth. Septic tank malfunctions and the presence of grease, oil and other floating material were found in six counties. At least half the counties reported contaminants in erosion, debris and litter, fish kills, heavy metals, low dissolved oxygen and nutrients.

  There is reason to believe that further investigation will show that certain contaminants exist in all counties. For example, debris and litter most likely occurs throughout the region.

- *WHAT IS THE NATURE OF THE PROBLEMS?*

  Quite obviously most surface runoff problems occur during the rainy season. The amount of rain and presence of contaminants in any given location determine the amount of pollution. Also, activities related to surface runoff occur at all times and at different loactions. Although a substantial amount of information has been accumulated, more work needs to be done on pinning down precise locations and causes of pollution.

  The nature of the problem (occurring in many locations in varying degrees) suggests that to a large extent control can be achieved through applying Best Management Practices (BMP). These practices are low-cost, non-structural control measures.

PROBLEMS IDENTIFIED BY THE MONITORING PROGRAM

This section is based on the local water quality data collected by the County Lead Agencies during the 1976-77 rainy season. The outline of this program was described in the Progress Report No. 1, "Summary of County Water Quality Sampling Program", November, 1976. The collected data and the analysis will be available soon in an upcoming staff report. The overview of this program, the collected data and the most significant results, presented below.

1. Program Highlights

The monitoring program conducted this year by the County Lead Agencies was the first regional surface runoff quality sampling program in the San Francisco Bay Area. The data was collected at 22 different sites distributed throughout the region. Prior to this program there was only one effort to collect surface runoff quality samples in the Bay Area. It was carried out in selected years from 1972 through 1975 by the USGS for the U.S. Army Corps of Engineers, and was limited to three watersheds.

The parameters sampled this year were selected to provide a representative balance among the major types of pollutants; nutrients, solids, bacteria, organics, metals and floatables. A balance was also sought between pollutants with immediate impact on the environment (organic matter, bacterial contamination), and those with long term effects (metals). In total 27 parameters were sampled. In most cases a division was made between the "core parameters" which were sampled throughout the season, and the "spot-check parameters" which were sampled during the first few storms only, and then discontinued if no problem was indicated by the initial results.

This year's program is generally considered a success. It is largely attributed to the fact that local agencies were involved in sampling the nearby streams. In total 12 agencies were involved. This includes, in addition to the eight participating counties, voluntary effort on the part of EBMUD, U.S. Army Corps of Engineers, USGS, and ABAG. The overall cost of the program, including data collection, processing, analysis and evaluation was slightly over $160,000.

2. The Available Data Base

Despite the drought a large number of data was collected. In total almost 600 stormwater samples were collected during 55 storm events. This constitutes about two-thirds of the total number of storms which were to be sampled. In addition, about 25 samples of baseflow were also collected.

The characteristics of the sampled watersheds range from flat dry plains to steep hills, including different sizes and dominant land uses. The summary of these characteristics and the number of individual samples collected is also given in TABLE 3.

TABLE 3

Overview of Sampled Watersheds

Land Use	Number of Watersheds	Size Range (Sq. Miles)	Number of Samples
Residential	13	0.2 - 164	305
Commercial	1	0.02	36
Industrial	3	0.03 - 0.14	75
Open & Agriculture	7	1.6 - 56	147

The location of the sampled watersheds is shown in FIGURE 1. The small amount of precipitation this year resulted in a large reduction in the volume of the surface runoff. The reduced surface runoff was especially acute in rural areas where greater infiltration capacity restricted stream flows to a small fraction of normal levels.

In addition to the samples collected this year, the data base used in the Surface Runoff Management Program contains about 150 samples representing about 25 storms (and some base flow data) at the Castro Valley Watershed. The data was collected during the 1971-72, 1972-73, and 1974-75. Since the same site was used for sampling this year, the comparison of data provided some insight into the effects of the drought on the collected data.

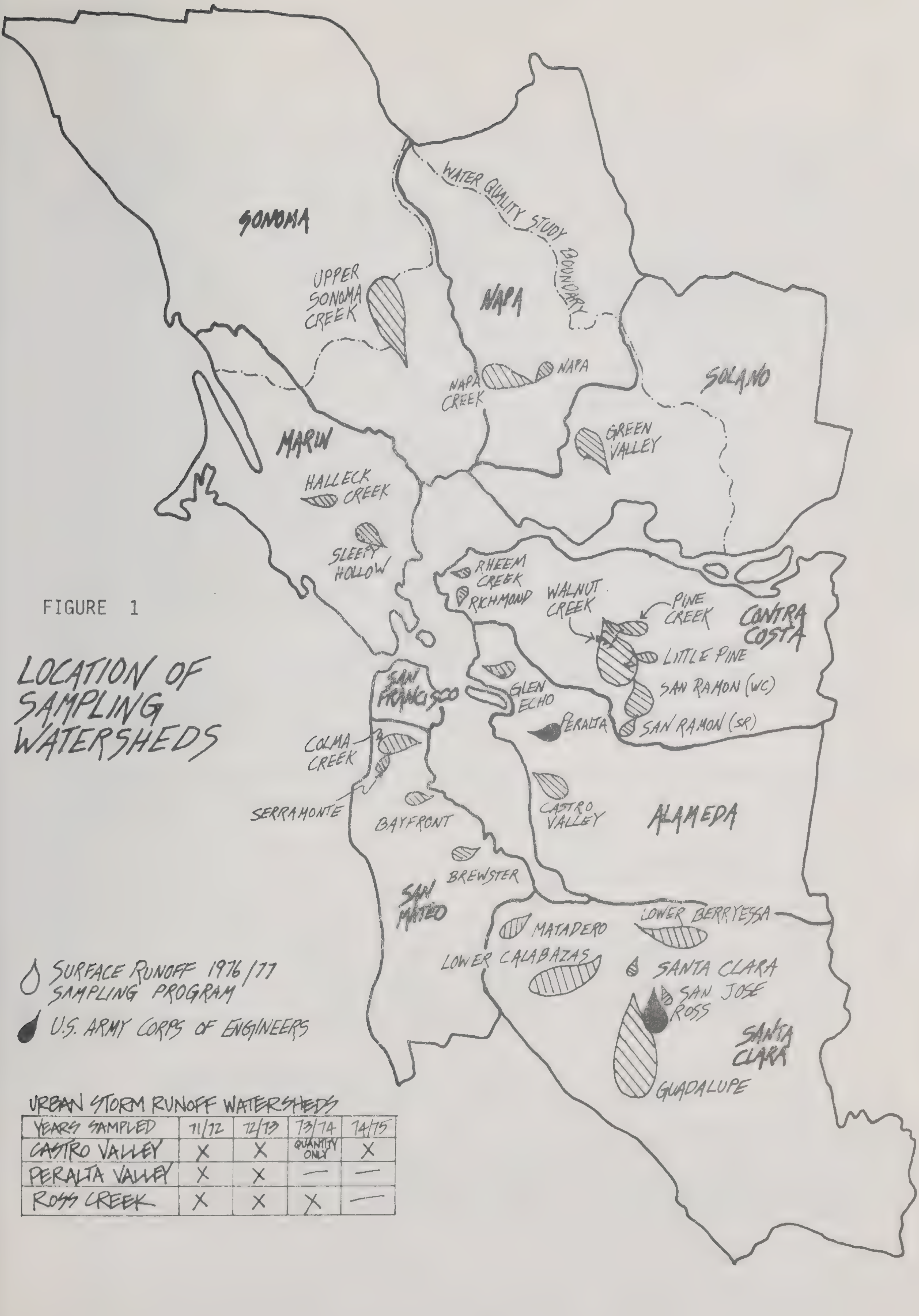
3. Major Findings - Concentrations of Various Pollutants

The most characteristic feature of surface runoff is the tremendous variability of water quality constituent concentrations. This variability decreases when a single land use is considered.

In general, the quality of surface runoff from urban areas is two to three times more polluted than surface runoff from open areas. The major exception to this is suspended solids. The open areas contribute signficantly higher concentrations of solids when compared with urban areas. Information regarding the concentration of pollutants from land uses is given in Appendix B. Information regarding the sources of surface runoff pollutants can be found in Appendix C.

FIGURE 1

LOCATION OF SAMPLING WATERSHEDS



SURFACE RUNOFF 1976/77 SAMPLING PROGRAM

U.S. ARMY CORPS OF ENGINEERS

URBAN STORM RUNOFF WATERSHEDS

YEARS SAMPLED	71/72	72/73	73/74	74/75
CASTRO VALLEY	X	X	QUANTITY ONLY	X
PERALTA VALLEY	X	X	—	—
ROSS CREEK	X	X	X	—

An expeditious assessment of the overall quality of surface runoff in the San Francisco Bay Area can be obtained by examining FIGURE 2. The range of concentrations of individual samples for all the monitored storms are illustrated by the length of the bars. These bars are plotted on different scales for different pollutants. The average concentrations from individual watersheds are represented by the circles within the bars. The solid circle denotes the average concentration for all land uses combined. Concentrations of the pollutants which are considered in the professional literature as damaging to the environment are represented by the shaded portion of the bar.[1]

As shown in FIGURE 2, most of the average pollutant values from individual watershed (open circles) are within the shaded portion of the charts. The average values are bordering or are located within the shaded portion. This indicates a general pollution problem throughout the region. However, the position of the average pollutant concentration within the bar charts is not always indicative of the <u>degree</u> of pollution. For example, the suspended solids concentrations in FIGURE 2 do not adequately reflect the seriousness of the regional erosion/sedimentation problem. During a normal rainfall year it is anticipated that the concentration of suspended solids in surface runoff will greatly increase.

Likewise, while the nutrient concentrations are shown to be high, they are not considered as a problem because in the Bay Area the total load of nutrients contributed by point sources is many times greater than surface runoff. Nevertheless, FIGURE 2 is quite informative for indicating high concentrations of pollutants. In particular it shows that the concentrations of oil and grease, organics, heavy metals, in addition to suspended solids are believed to represent the major pollution problems from surface runoff.

The large amount of data gathered through the monitoring program stimulates a variety of questions. The questions of special significance and interest are listed below with their answers.

- *IS THE SURFACE RUNOFF POLLUTED?*

  Although no definitive standards for surface runoff are available the answer is in most cases 'yes'. TABLE 4 compares the quality of typical treated and untreated sewage with the average quality of surface runoff. The treated sewage discharge complies with Federal point source effluent limits. It is apparent that surface runoff is more polluted than treated sewage with respect to most constituents.

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[1] The criteria for "damaging" are derived from independent research studies and various State and Federal water quality standards. They are intended here as a comparative tool to show areas of general concern. They do not represent actual violations of standards.

FIGURE 2 MEAN AND RANGE CONCENTRATIONS OF THE SAMPLED DATA

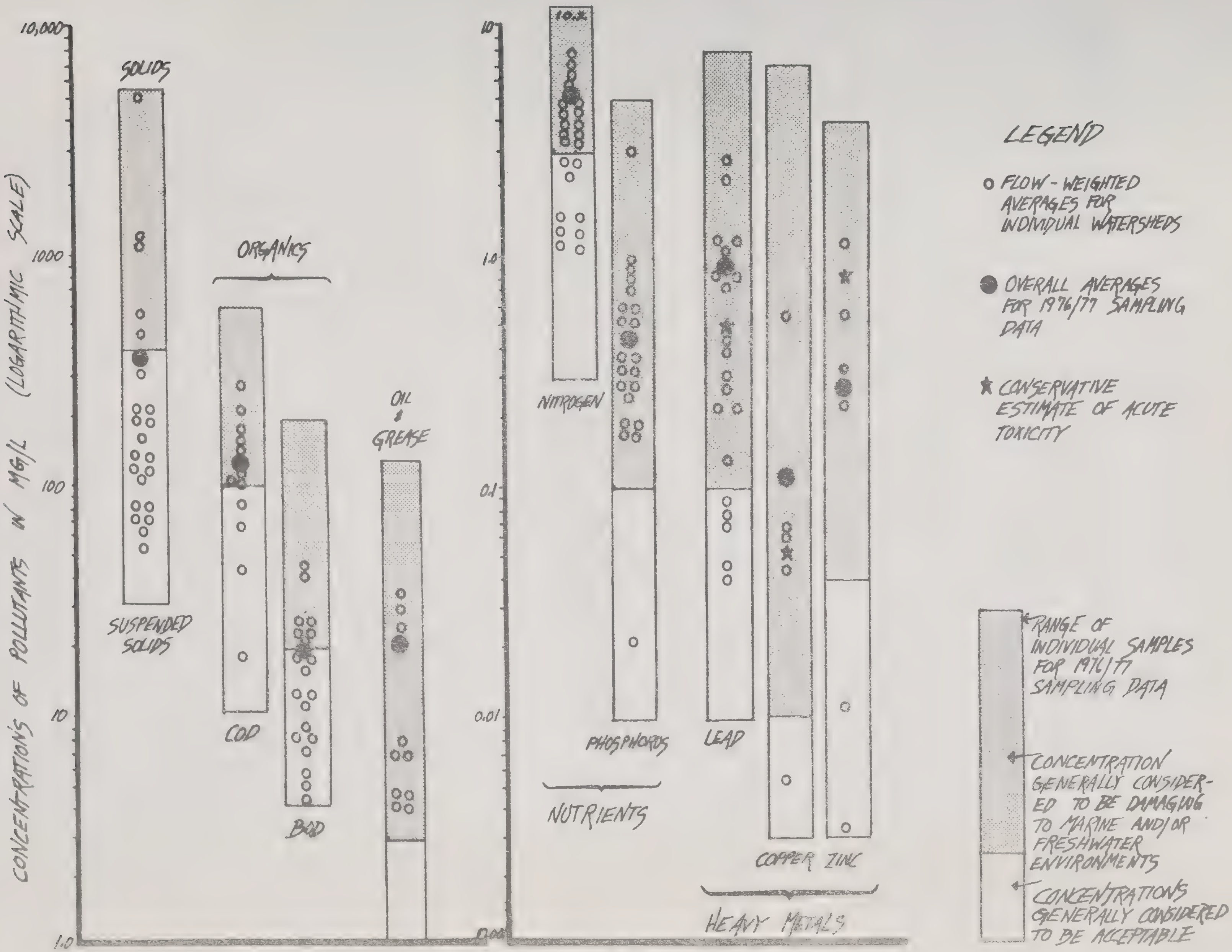


TABLE 4

QUALITY COMPARISONS OF SURFACE RUNOFF
AND WASTEWATERS

Type	BOD	COD	SS	VSS	TN	TP	Total Coliforms	Oil & Grease
Surface Runoff	18	140	370	66	4	1	245,000	19
Secondary Effluent*	25	55	20	15	30	5	300	8
Untreated Sewage*	200	500	200	-	40	10	50,000,000	-

- *HOW DOES THE LAND USE AFFECT SURFACE RUNOFF?*

Different land uses generate different amounts of pollutants. The answer is examined in light of four categories of land uses: residential, commercial, industrial and open space. There appeared to be relatively minor differences in the quality of surface runoff in the three urban land uses. Residential, commercial and industrial land uses produced high concentrations of organics, nutrients, heavy metals and floatables. The open areas, which include both natural undeveloped areas and agricultural land, produced lower amounts of these pollutants (with the exception of nutrients) but produced larger amounts of sediment.

- *HOW DOES THE INTERVAL BETWEEN STORMS AFFECT THE QUALITY OF SURFACE RUNOFF?*

Local surface runoff data from this year tends to support the belief that pollutant concentrations from <u>urban</u> sources reach a maximum amount in a short period following a storm. FIGURE 3 shows an example of BOD concentrations from storms with various preceeding dry periods. It is evident from this figure that pollution in storms after a short dry period (two weeks or less) is about the same as pollution in storms after a much longer dry period. Similar results were observed in other locations monitored as part of this year's sampling program. These local results are supported by an EPA study conducted nationwide (FIGURE 4). the question of pollutant accumulation on rural lands is not comparable to that in urban areas. On rural lands, pollutant concentrations in runoff are more closely related to storm intensity than time interval between storms.

*Source: EPA, 1974. Urban Stormwater Management and Technology, Cincinnati, Ohio.

FIGURE 3

Glen Echo, Alameda County

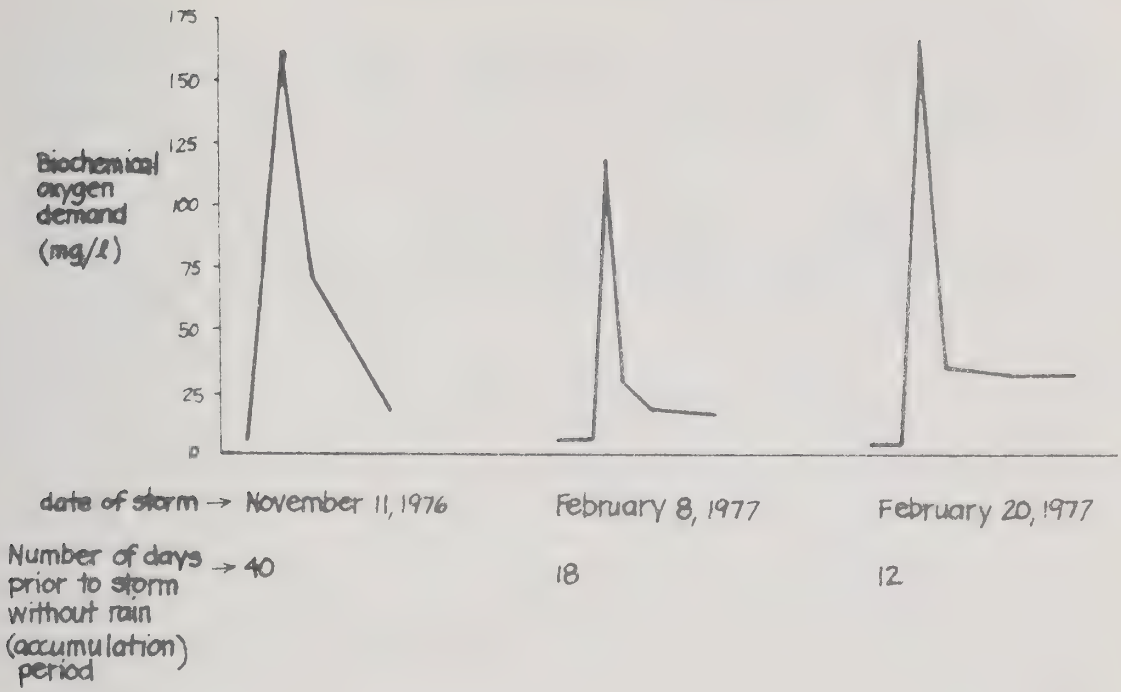
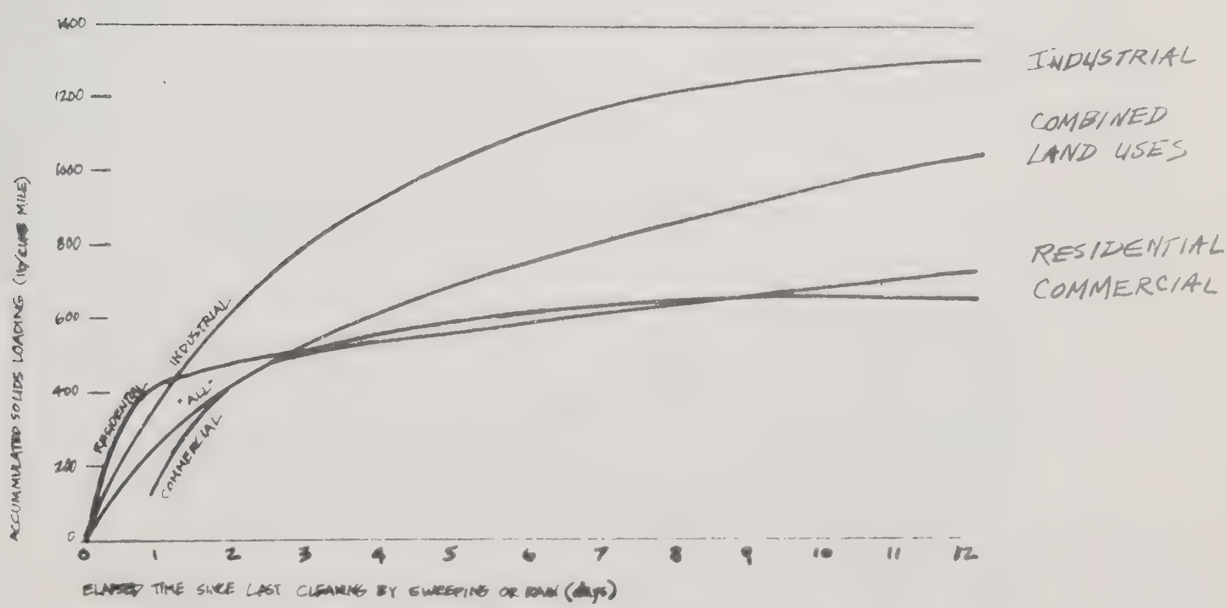


FIGURE 4

ACCUMULATION OF POLLUTANTS SINCE LAST CLEANING BY SWEEPING OR RAIN



SOURCE: WATER POLLUTION ASPECTS OF STREET SURFACE CONTAMINANTS BY J.D. SARTOR AND G.B. BOYD, EPA R-2-72-081, NOVEMBER 1972

- *HOW DOES THE DROUGHT AFFECT THE COLLECTED DATA?*

Perhaps not very much. Since pollutant levels in urban areas do not accumulate indefinitely, the values obtained from our sampling program would probably not be significantly different in a normal rainfall year.

Specific evidence in support of this conclusion is provided by the data collected at the Castro Valley site in Alameda County. The results obtained during this drought year at that site were very similar to what was found in the previous years (TABLE 5).

TABLE 5
Castro Valley Surface Runoff Data

CASTRO VALLEY	BOD	COD	SS	TN	TP	OIL
Army Corps Data for FY 72, 73, 75	31	170	896	4.7	0.8	7.8
Alameda County Surface Runoff 1976-77	26	156	340	4.1	-	7.4

Other evidence is provided by the URS Corporation study on pollutant accumulation on streets in the San Francisco Bay Area. This data was used by the San Francisco Regional Water Quality Control Board to develop pollutant emission concentrations for all land uses. They were subsequently used in the BASIN PLAN. As evident from TABLE 6, they compare surprisingly well with this year's surface runoff quality data.

TABLE 6

Pollutant Concentrations from Basin Plan Compared to Local Surface Runoff

Average Total Pollutant Conc.	BOD	COD	SS	TN	TP	LEAD	OIL
BASIN PLAN (75) RWQCB (from URS)	19	140	373	3.5	0.56	0.79	11
Surface Runoff Monitoring (76-77)	18	140	370	3.9	0.5	0.72	19

- *HOW DOES THE LOCAL DATA COMPARE WITH SAMPLING CONDUCTED NATIONWIDE?*

Overall, the data collected locally compares rather closely with national averages. The major difference is in suspended solids which was expected because the light rainfall produced lower than normal runoff. Since suspended sediment concentrations are closely related to stream discharge, it is understandable that suspended solids are also lower than might be expected (see TABLE 7).

TABLE 7

Pollutant Concentrations from National Data Compared with Local Data

Storm Water Concentrations	BOD	SS	TN	TP	COLIFORMS
National Pollutant Concentrations* from Separate Sewered Cities	27	608	2.3	0.5	3×10^5
Urban Surface Runoff Data 1976-77	22	206	4.8	0.5	2.5×10^5 (Residential)

*EPA, 1976, Areawide Assessment Procedures Manual, Vol I.

- *HOW WOULD THE CONCLUSIONS DIFFER IF WE HAD ANOTHER YEAR OF DATA (ASSUMING A NORMAL RAINFALL YEAR) ?*

Probably the overall assessment would not change much. Data from the Castro Valley Watershed during years with "normal" rainfall showed pollutant concentration both above and below the values for that same watershed this year.

However an additional year of sampling is extremely important for further identification of specific problems and for evaluating the effectiveness of surface runoff control measures. Also, the additional sampling will be particularly important in the open and agricultural lands, where minimal flow occured this year. It is expected that with greater flow the erosion rates will also be greater, resulting in higher concentrations of certain water quality parameters.

REGIONAL ANALYSIS OF POLLUTANT LOADS TO THE BAY

This section is primarily based on the results of the modeling efforts with the MAC Model. Application of this model to the Bay Region has been continuously refined over the past months. Initial runs were made from November through January using the preliminary 1970 land use data base and national quality coefficients. Later, in February and March, the 1970 data base was updated to 1975 and reviewed by the County Lead Agencies. Also, partial revisions of the national quality coefficient were made in these runs. Finally, in April and May, the national coefficients were replaced with local sampling data from this year's monitoring program, and the revised Series 3 land use projections for the target years 1975, 1985 and 2000 became available. The results presented below are based on the latest runs of the MAC model.

1. Background

Prior to examining the results of the modeling program it is appropriate to review the rationale for the use of mathematical models in the Surface Runoff Management Program. The answers to the most frequently asked questions are given below.

- *WHY A NEED FOR A MODELING PROGRAM?*

  Mathematical models offer the most comprehensive approach which can address:

  - the size and complexity of the system analyzed
  - the need for consistency between the analytical techniques used by each county
  - the scarcity of data, which calls for the meaningful transfer of data from one location to another.

- *WHAT ARE MATHEMATICAL MODELS?*

  Mathematical models are a simplified representation of a real-world physical system. They use a linkage of cause-effect relationships represented in mathematical form. Models follow operating rules without exception or interpretation. They use high speed digital computers and can process enormous amounts of data with relative ease.

- *WHAT ARE THE ALTERNATIVES TO MODELING?*

  Basically there are no alternatives. Field surveys, monitoring, interviews (public sense of the problem), etc., are important and needed supporting

tools . However, when they become a primary tool they invariably introduce ambiguity, inconsistency and abstraction. For example, when an observer views a condition in a stream, is that observation representative of what it would have been a week ago? A year ago? Ten years in the future? A mile downstream or upstream? A parallel stream a mile away? How then can he arrive at a conclusion and, if he does, would another observer make the same interpretation?

Mathematical models can avoid or minimize many of these problems and can benefit from the collective efforts of all observers, both within the study area and nationwide, as well as provide a base for continuing programs.

- *WHAT ARE MODEL LIMITATIONS AND RISKS?*

Although the mathematical models are based on a solid engineering understanding of watershed hydrology and have been widely tested, they should be used carefully. In particular, it is important to remember that the reliability of these models is directly related to the reliability of their inputs. Therefore, the models should be calibrated and checked against the historical flow and quality of records. If this is done, the decision-maker can expect that the models can properly assess the relative ranking of pollution. Unfortunately, model calibation or verification requirements cannot always be met, particularly when field data sources are limited. In such cases, the uncertainty of the model's predictions increases and it is necessary to weigh these uncertainties against the uncertainties of other sources of information.

- *WHAT MODELS ARE USED IN THIS PROGRAM?*

Two mathematical models are being used to relate land activities to the quality and quantity of surface runoff. One is a general model, applied to the entire region. It is known as the "MAC" model (short for "macroscopic"). MAC has the following characteristics:

- It is applied to each individual watershed in the entire region. (The region has been divided into 108 MAC watersheds.)

- Inputs

  - A rainfall pattern for a particular period
  - Land use in the watershed
  - Coefficients relating land use to the concentration of the pollutants of interest
  - Coefficients relating the quantity of runoff to the amount of rainfall

  Both sets of coefficients are being adjusted based on data collected in this region.

- Outputs

  - The total amount of runoff for the rainfall period
  - The total amount of each pollutant for the rainfall period

  MAC is most accurate when applied to an entire season of rainfall. It also produces monthly results which are less accurate than the annual totals.

The other model is the EPA Storm Water Management Model (SWMM). It is more detailed and it is applied to specific demonstration watersheds. This model will be of particular importance in evaluating the effectiveness of individual control measures. To date, its results are only preliminary and are not included here.

A detailed description of the two models, and the initial results are presented in the Progress Report #2, "Summary of Surface Runoff Modeling Program," dated February 28, 1977.

2. Regional Summary of MAC Modeling Results

A considerable amount of data was produced by the modeling analysis. The following three items present the most significant results in a question and answer format.

- *HOW DO POLLUTION LOADS FROM SURFACE RUNOFF COMPARE WITH POINT SOURCE LOADS?**

  a. Suspended solids loads from surface runoff are considerably higher than treated point source loads in all counties. In fact, loads from surface runoff also exceed untreated point source loads. Surface runoff produces more than 20 times as much suspended solids as do point sources after treatment. This ratio is expected to remain about the same through the year 2000.

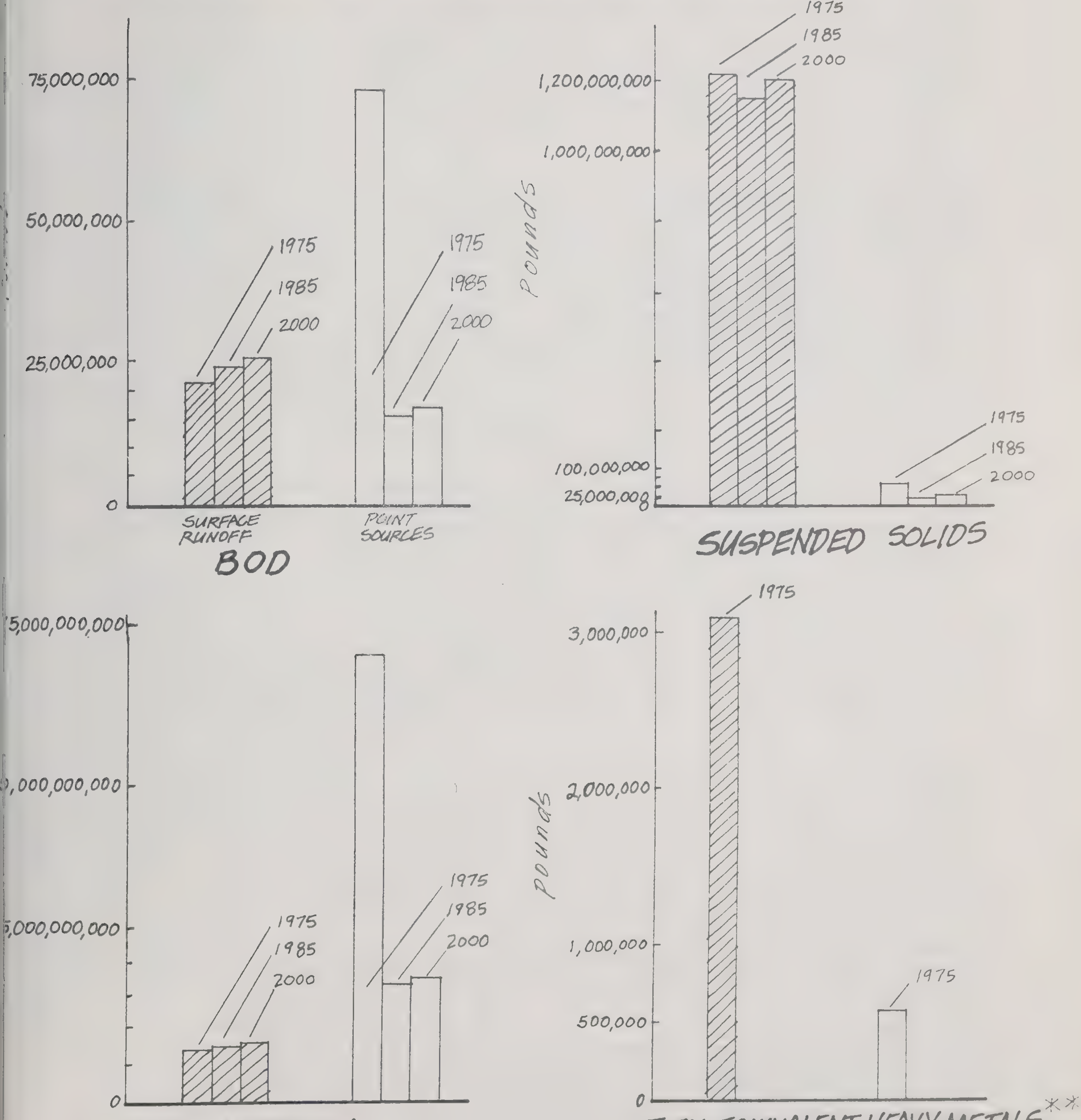
  b. Surface runoff contributes substantially more heavy metals to the Bay than point sources. Calculations of equivalent heavy metals (see footnote, figure 5) from both sources show that surface runoff produces more than four times as much heavy metals.

  c. On a regional basis, BOD from surface runoff now accounts for about 25% of the total BOD load to the receiving waters. This figure is expected to rise to 60% in 1985 as treatment efficiencies improve and remain at that level through the year 2000 (see figure 5). Thus, during

*NOTE: All conclusions under this question are based on comparisons made for an assumed 6-month rainy period (November-April).

FIGURE 5

REGION-WIDE COMPARISON OF PRESENT AND FUTURE POLLUTANT LOADS FROM SURFACE RUNOFF AND POINT SOURCES*



Includes all counties except San Francisco. Comparisons made for an assumed 6-month rainy period.

Total equivalent heavy metals is a weighted summation based on metal toxicities. See W.Q. Tech. Memo #7, 2/24/77. Projections for 1985 and 2000 are not yet available.

the 6 month rainy season, about 1½ times more BOD will come from surface runoff than from point sources.

d. In the rural counties (Marin, Napa, Solano and Sonoma), more BOD is produced by surface runoff than by point sources. In the urban counties (Alameda, Contra Costa, San Mateo and Santa Clara) the BOD loads from point sources are substantially greater than from nonpoint sources in 1975. By 1985 loads from the two sources will be nearly equal. This relationship is projected to hold through the year 2000 (see Figure 6).

e. The percentage of the total nutrient load (nitrogen and phosphorus) produced by surface runoff is much smaller than for suspended solids and BOD. In a regional basis (in 1975), surface runoff contributed only 1% of the total phosphorus load and 9% of the total nitrogen load. These figures are projected to increase to 7% and 28% respectively in the year 2000 as nutrients removal efficiencies in treatment plants are improved. In three of the four rural counties, however, more nitrogen is and will be produced by surface runoff than by point sources (see Figures 5 and 6).

- *DO URBAN AREAS PRODUCE MORE POLLUTANTS THAN RURAL AREAS?*

In general the answer is 'yes'. It varies, however with the county and the pollutant being measured. In the case of BOD, the urban portions of Alameda, Contra Costa, Santa Clara and San Francisco counties produce the most pollution (see Figure 7 and Table 8). The urban land uses constitute approximately 25% of the land area in these four counties and they produce about 75% of the BOD load from surface runoff. In the other counties, more BOD comes from the open and developable areas. On a regional basis 49% of the BOD in surface runoff comes from urban sub-watersheds and 36% from open sub-watersheds (see footnote on Figure 7 for explanation of "urban," "developable" and "protected" (open) sub-watersheds).

In the case of suspended solids, the heaviest loads come from the open areas. The amount of solids washing off rural areas is strongly related to the amount and intensity of rainfall. Thus, the explanation that can be given to the obtained results is that the open lands in the northern counties (where rainfall is greater) tend to produce more solids than open lands in the southern counties. Although further modeling analysis of suspended solids will probably be necessary in a few counties, the results to date show that on a regional basis about 70% of suspended solids are produced by the open sub-watersheds. In Marin County, which has the highest annual rainfall, 96% of the suspended solids come from the open areas.

For nutrients (nitrogen and phosphorus), the urbanized portions of the urban counties (Alameda, Contra Costa, San Francisco and Santa Clara) produce the highest loads. On the average, about 70% of the nutrient load from these counties comes from their urban areas. In the more

COMPARISON OF SURFACE RUNOFF & POINT SOURCE POLLUTION LOADS BY COUNTY

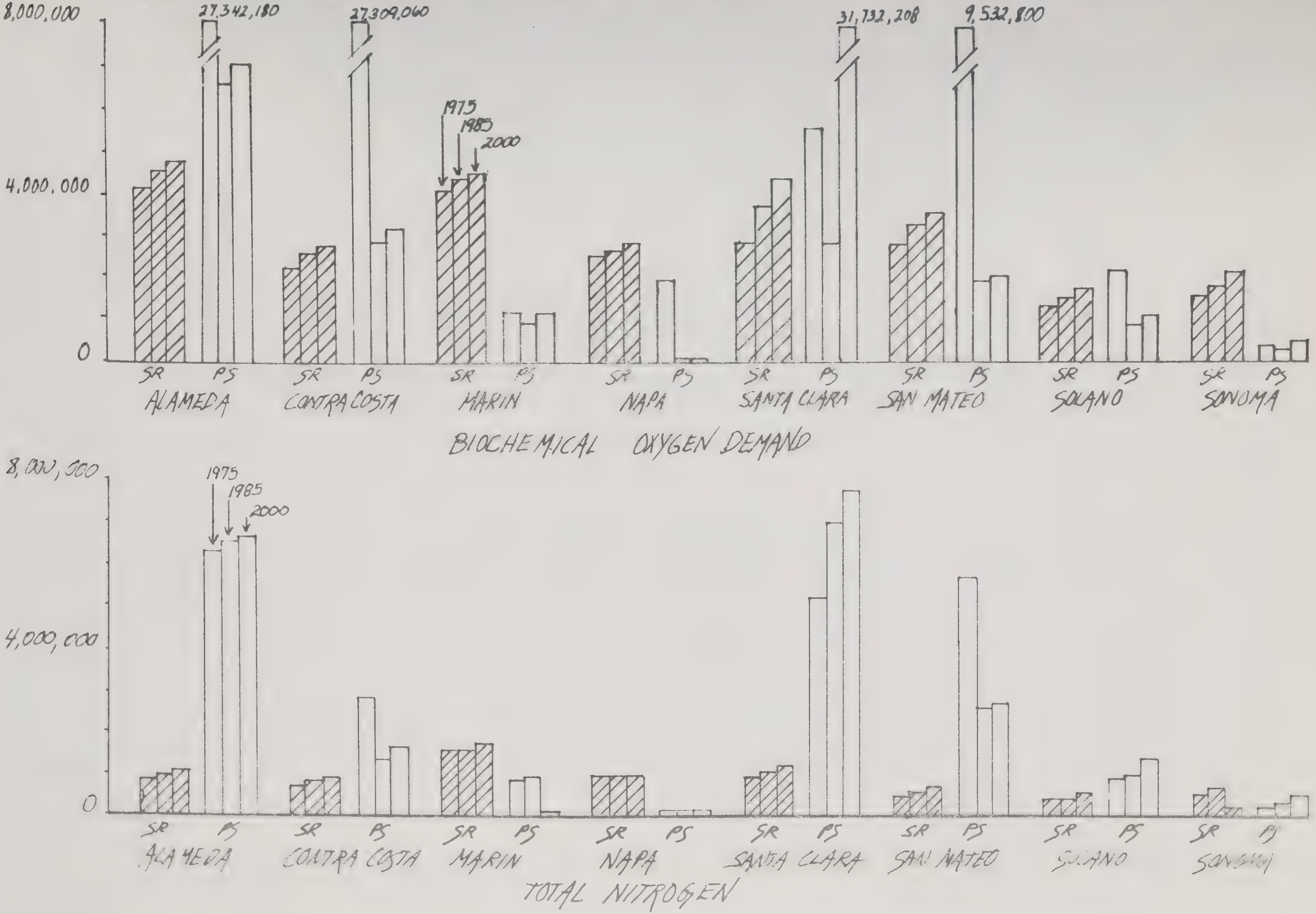
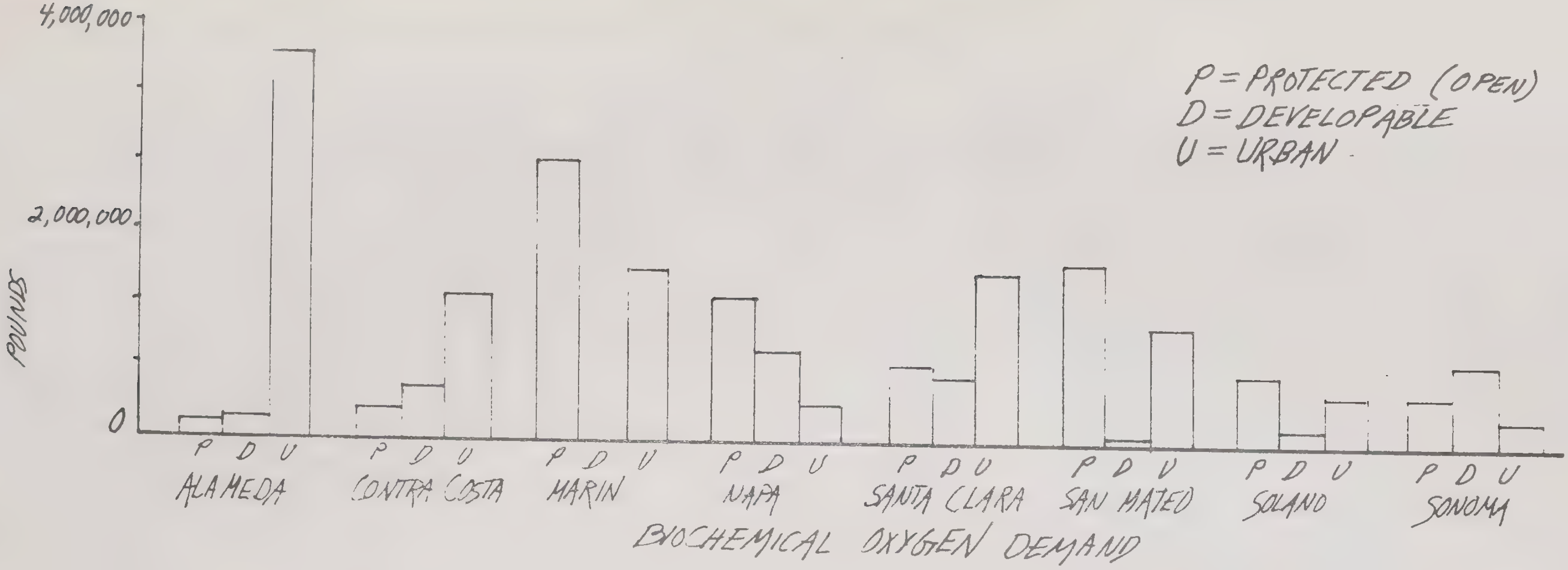


FIGURE 6

SURFACE RUNOFF LOADS FROM MAC SUB-WATERSHEDS *



* MAC watersheds are broken down into 3 subdivisions. The "urban" sub-watersheds are at present primarily urbanized. "Developable" sub-watersheds are either partially developed at present or are likely to be developed in the future (i.e., urban fringe areas). "Protected" sub-watersheds are major open space areas (they do not include open areas or parks within cities).

FIGURE 7

TABLE 8

Percent Contributions From MAC Sub Watersheds to Total County Pollutant Loads. (1975)

Counties	Watershed Sub-Area	Acres	% of Co.Area	% Contribution to Total County Loads		
				BOD	TN	TP
Alameda	urban	166703	27%	91%	88%	78%
	developable	46171	8	6	6	9
	open	400322	65	3	6	13
Contra Costa	urban	92588	26	61	51	49
	developable	128447	35	27	31	32
	open	143296	39	12	18	19
Marin	urban	27861	9	37	24	20
	developable	---	---	---	---	---
	open	273052	91	63	76	80
Napa	urban	12300	5	15	5	6
	developable	62500	23	31	38	52
	open	191300	72	54	57	42
San Francisco	urban	17537	100	100	100	100
	developable	---	---	---	---	---
	open	---	---	---	---	---
San Mateo	urban	46333	31	38	23	54
	developable	7523	5	3	3	3
	open	95326	64	59	74	43
Santa Clara	urban	165274	20	58	45	44
	developable	148245	18	19	21	21
	open	52537T	62	23	34	35
Solano	urban	13652	7	40	27	25
	developable	25835	12	10	11	12
	open	167545	81	50	61	63
Sonoma	urban	6685	4	17	10	7
	developable	85803	49	49	51	52
	open	82694	47	34	39	41

rural counties, only about 20% of the nutrient load comes from their urban portion. This result is attributable to the fact that these counties have relatively high percentages of open land and to the fact that on a per acre basis, urban and rural land produce about the same nutrient loads in surface runoff.

- *DO SOME COUNTIES PRODUCE MORE POLLUTANTS THAN OTHERS?*

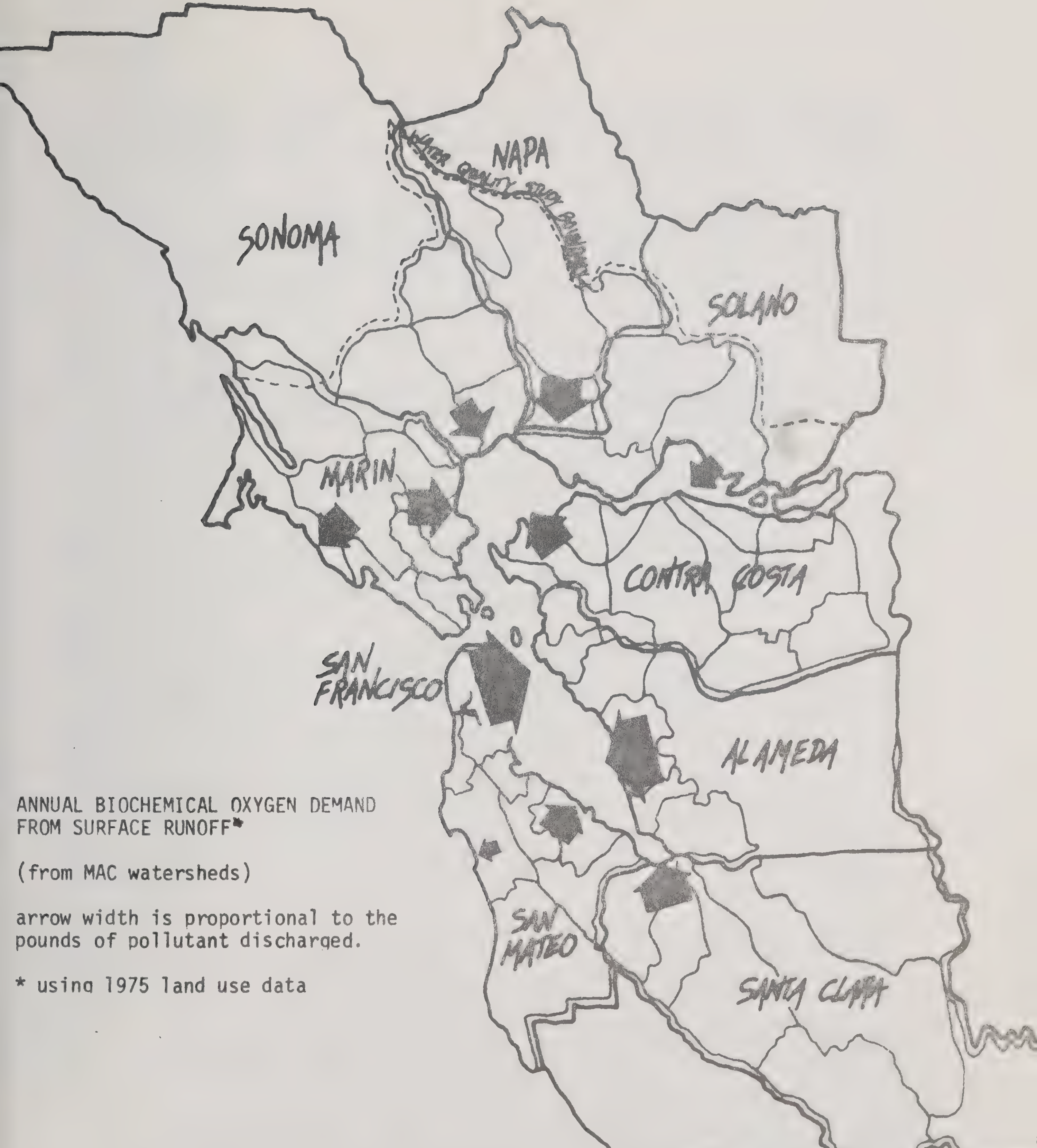
Yes. Figure 6 and Figure 8 show the relative BOD contributions from each county to the Bay and ocean. Table 9 indicates the percentage contribution of each county to the total BOD, nitrogen and phosphorus loads to San Francisco Bay.

TABLE 9

County Percent Contributions to Total Surface Runoff Pollutant Loads to San Francisco Bay (1975)

COUNTY	BOD	TN	TP
Alameda	14%	14%	11%
Contra Costa	11%	11%	10%
Marin	10%	11%	10%
Napa	11%	16%	17%
San Francisco	20%	8%	16%
San Mateo	8%	6%	8%
Santa Clara	13%	16%	13%
Solano	6%	8%	7%
Sonoma	7%	10%	8%

From these figures it is evident that the greatest BOD loads to the Bay and ocean are produced by San Francisco, Marin and Alameda counties. San Mateo, Santa Clara, Napa and Contra Costa counties produce smaller loads, followed by Sonoma and Solano counties. These last two counties produce the smallest loads largely because only a small portion of their areas drain to the Bay.



ANNUAL BIOCHEMICAL OXYGEN DEMAND FROM SURFACE RUNOFF*

(from MAC watersheds)

arrow width is proportional to the pounds of pollutant discharged.

* using 1975 land use data

FIGURE 8

When the focus is on the total BOD loadings to the Bay, San Francisco County is found to produce the greatest amounts, followed by Alameda, Santa Clara, Napa, Contra Costa, San Mateo, Marin, Sonoma and Solano counties respectively.

There are several reasons why the loadings vary considerably from county to county. Figure 9 presents a series of bar graphs showing the relative areas, rainfalls, runoff factors and runoff volumes among the counties. In reviewing these bar diagrams the following should be kept in mind:

1. More rainfall produces more runoff.

2. The greater the amount of land surface draining to a water body, the greater the volume of runoff will be to that water body.

3. The more impervious a land surface is, the greater the volume of runoff.

4. Land that is saturated with water (i.e., from frequent or heavy rains) is more impervious than drier land (i.e., more water will run off of it).

Figure 9 shows that the northern counties (Marin, Sonoma and Napa) experience substantially higher rainfalls than the other counties. Thus, with other factors being equal, these counties should produce the highest pollutant loads per acre. The top graph in this figure shows that Santa Clara County has the greatest acreage draining to the Bay, followed by Alameda, Contra Costa and Napa counties respectively. The other five counties have considerably smaller drainages to the Bay. Thus, with other factors being equal, one would expect runoff volumes proportional to these acreage figures. However, several factors counteract this relationship. First, reservoirs prevent runoff from reaching receiving waters (when they are not full) and Santa Clara County has an extensive reservoir network.

Second, the counties with the largest drainages to the Bay have the smallest annual rainfalls. For example, Marin (area draining to Bay only), has only one-third the area of Santa Clara. However, Marin has twice the annual rainfall and a 50% greater (experienced) runoff coefficient. Thus, it produces a greater total runoff than its larger and more urbanized neighbor. This volume, with the applied simulation factors, was sufficient to offset the more concentrated BOD runoff from Santa Clara.

Third, San Francisco County has a combined storm and sanitary sewer system. Present wet weather overflows of treatment plant capacity account for the high BOD loads from this county.

RELATIONSHIP OF RUNOFF VOLUME TO DRAINAGE AREA, RAINFALL AND RUNOFF COEFFICIENT

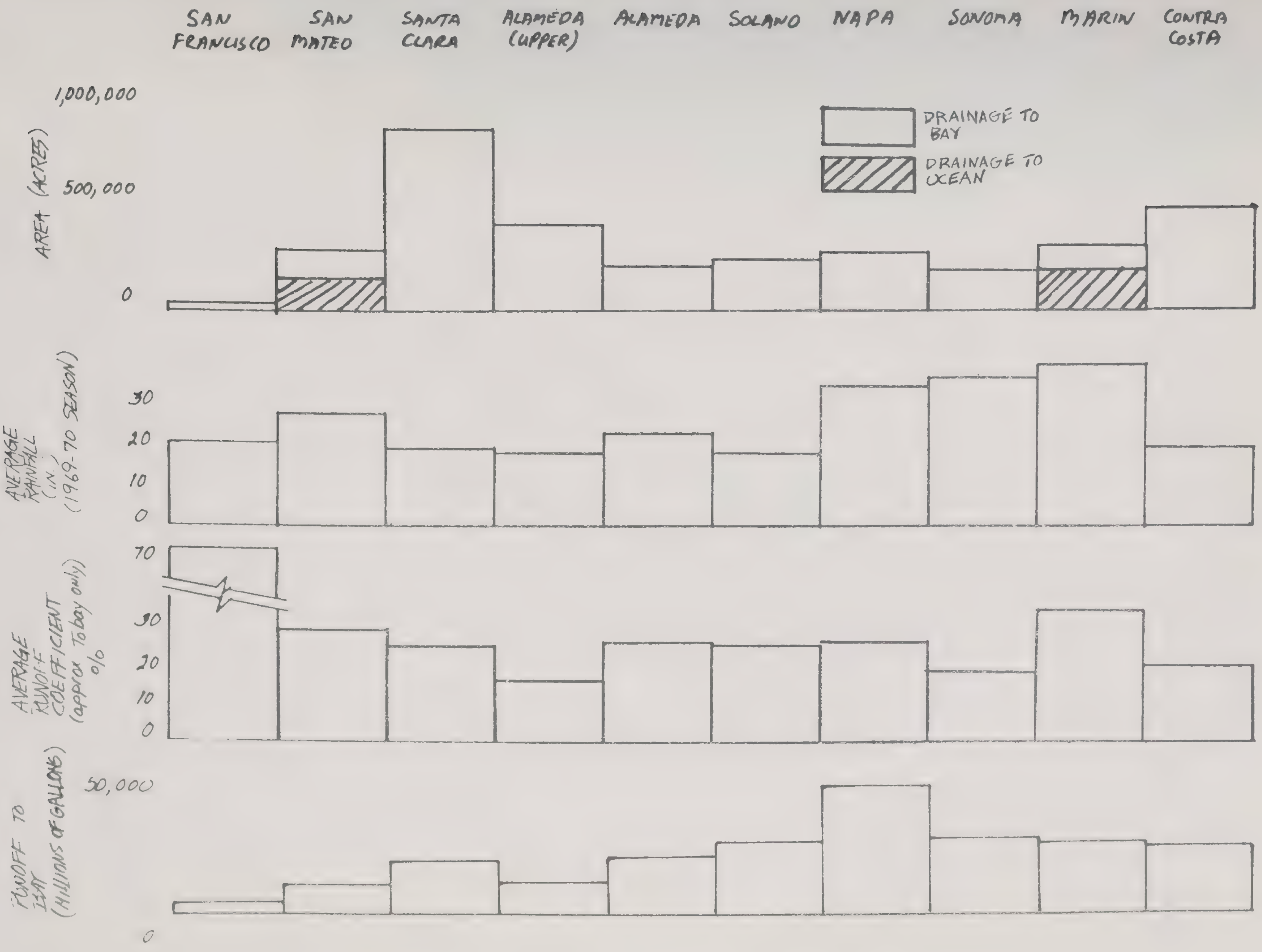


FIGURE 9

The analysis of suspended solids loadings produced by individual counties is not final.* Possible inconsistencies were found in the most recent runs of the MAC model. Additional consultation among the counties, ABAG, and its modeling consultants is needed before a final set of conclusions on this constituent can be drawn.

*See item 2 under Program Progress (App. D).

APPENDIX A

MAJOR FINDINGS OF SURFACE RUNOFF PROBLEMS BY COUNTY

COUNTY: ALAMEDA

SOURCE:

- Progress Report #3, "Examination of Existing Water Quality Problems in Alameda County," February 28, 1977, 50 pp.
- Progress Report #12, "Examination of Future Water Quality Problems in Alameda County," June 3, 1977, 19 pp.

MAJOR FINDINGS:

1. In general, existing and future surface runoff (non-point) loads contribute significant quantities of water pollutants compared to municipal sewage treatment plants.

Specifically, runoff contributes approximately 40% of the total oxygen demand released (from Alameda County) to San Francisco Bay during the wet season. Nutrient non-point loads (total nitrogen and phosphorus) represent about 20% of the combined point and non-point seasonal load.

2. The predominant quantities of storm runoff pollution entering San Francisco Bay originate from the urban areas. In other words, along Alameda County's Bay Plain urban runoff is the concern. The only exceptions are sediments which are also generated in large quantities in the rural, east county area

3. The quantities of surface runoff pollution do not appear to significantly increase during the 1975 to 2000 investigation period, i.e. the present problems are also the future problems. This implies that mitigation measures in Alameda County should be directed at existing development. The exception is the erosion problem caused by residential development in the hills. Temporary disturbance of the land surface creates unusually high sediment loads during the construction period.

ABAG STAFF COMMENTS:

Staff is in agreement with the findings of Alameda County. The effort placed by Alameda County on detailed problem identification will contribute greatly towards the eventual control of these pollution sources. Some of these specific findings and their impacts on local receiving waters are shown on the following two pages

Bacteria: The problem of bacterial contamination of intra-county surface waters is well documented. It is of significant concern because it affects water contact recreation in local surface waters.

Monitoring data gathered this year (at Glen Echo and Castro Valley Creeks) confirms signficant, substantial concentrations and quantities of bacteria in urban runoff. Both animal and human feces are assumed to be the source. Some of the fecal/fecal streptococci ratios from the Oakland monitoring site suggest human feces. It is further assumed that sanitary sewer overflows, cross connections or exfiltration are responsible. Further investigations as to sources will become a part of the continuing planning process.

Heavy Metals: Heavy metals, particularly lead, zinc, copper and manganese, which are released into the receiving waters, result overwhelmingly from non-point sources. Their quantities are considerable (see Table A-1), but the specific chemical forms of these metals are not known at this time (and will not be known in the foreseeable future). For example, the toxicity of copper is dependent upon its chemical form, i.e. Cu^{+6} is highly toxic, Cu^{0} is not toxic.

Most of the beneficial uses (which local regulatory policies have sought to protect) are known to be vulnerable to even relatively small amounts of these toxic, heavy metals. However, their sources and toxcity levels are not known with certainty. As a result, there is concern about controlling their discharge. In particular, because:

- The specific chemical forms of the discharged contaminants are not known.

- There is a considerable uncertainty regarding the receiving waters' tolerance for such materials. It is known, however, that these metals tend to be concentrated as they pass through successive links of the food chain (concentrating by factors of thousands to one).

- Some of the relatively harmless chemical forms are subject to change into harmful forms (particularly while they reside in deposits of bottom sediments). As a result there is a possibility that toxic substances could be discharged to receiving waters for some time with no observable effect. Conditions could eventually change such that adverse conditions may develop.

Sediments: Existing and future storm generated sediment loads appear considerable. During average rainfall years, approximately 245 million pounds of soil will be deposited into San Francisco Bay from Alameda County. This translates into about 120,000 cubic yeards of material. The implication of this sediment deposition is directly linked to expensive maintenance costs of dredging harbors and flood control channels.

Nutrients: The predominant sources of nutrients are the existing treatment plants. The total nutrient load generated by surface runoff appears to be less significant. However, in certain areas these quantities might be significant and result in problems affecting the local receiving waters.

Organics: Surface runoff generates a large load of organic materials when compared with point sources. The 1975 BOD comparisons of point versus non-point sources will change dramatically in 1978 as higher treatment standards are implemented for point sources, particularly by EBMUD.

DRAFT

TABLE A-1

IMPACTS OF SURFACE RUNOFF ON LOCAL RECEIVING WATERS (Alameda County)

RECEIVING WATERS	Tributary Land Use	Tributary Land Area	Suspected W.Q. Constraints	Trend	Probable Source	In Jeopardy Use Why	Existing Uses	Potential Uses
CREEKS								
Alameda Creek	O	L	N, Salts, P & Sd	St	Treated effluent	Yes GWR effluent	AGR, GWR, REC, F&W	MIGR SPWN
San Lorenzo Creek	O	M	None	Ws		NK	REC, F&W MIGR, SPWN	
San Leandro Creek	O Above Chabot Dam R-C-I Below	M	B Mt	St	Urban runoff	NK	F&W	REC, SPWN, MIGR
LAKES								
Lake Elizabeth	R-O	M	None	Ws		NK	REC F&W	
Cull Canyon Reservoir	O	S	Sd	Ws	Ag,& Nat. erosion	Yes REC,F Sd	REC F&W	
Lake Chabot	O	M	N	St		NK	MUN, AGR, REC, F&W	
San Leandro Reservoir	O-R	M	NK			NK	MUN F&W	REC
Lake Merritt	R-C	S	N,OD, B,Sd	St	Sewage & Urban runoff	Yes REC,F&W, Sewage Runoff	REC F&W	
Lake Temescal	R	S	B,Sd	St	Urban runoff Dev. & Nat. erosion	Yes REC, F runoff	REC F&W	
Aquatic Park (Berkeley)	R-C-I		NK	St		NK	REC	
Don Castro Reservoir	O	M	None	Ws		Yes REC, F Silt	REC F&W	
The Lagoon (Alameda)	R	S	NK	St		NK	REC	
The Lake (Newark)	R	S	NK	St		NK	REC	
BAY								
Alameda Estuary	R-C-I	M	NK	St		No	REC	
San Leandro Bay	R-C-I	M	B, Sd Mt	St	Sewage, urban runoff	NK	REC F&W	

LEGEND

C - Commercial
I - Industrial
R - Residential
O - Open Space
S - Small(less than 10 mi^2)
M - Medium (10-100 mi^2)
L - Large(more than 100 mi^2)
St - Stable
Ws - Worsening
B - Bacteria
Mt - Heavy Metals
N - Nutrients
Sd - Sediment
OD - Oxygen Demand
P - Pesticides
REC - Recreation
GWR - Groundwater Recharge
AGR - Agricultural Water Supply
F - Fish Habitat
W - Wildlife Habitat
MUN - Municipal Water Supply
SPWN - Fish Spawning
MIGR - Fish Migration Route
NK - Not Known

COUNTY: CONTRA COSTA

SOURCE: Examination of Future Water Quality Problems in Contra Costa County (technical portion), June 13, 1977, 9 pp.

MAJOR FINDINGS:

1. Open space is a much greater factor than originally postulated in the magnitude of pollutant loadings upon the receiving waters.

2. The relationship of surface runoff loadings to point discharge loadings is substantially less than heretofor postulated in the Bay Basin Plan or in the ABAG Work Plan for the Environmental Management Plan.

3. The influence of loadings by Delta outflows is a dominant factor of such magnitude as to suggest a need to reconsider the definition of pollutants.

ABAG STAFF COMMENTS:

1. It is acknowledged that the influence of open space (agriculture and natural areas) is considerable. It is possible that, with respect to open areas, the suspended solids quality coefficient used by Contra Costa in the MAC model may be too low.

2. While the point source loadings compared to surface runoff loadings may vary from one county to another, the regional assessment of point vs nonpoint pollution presented in both the Bay Basin Plan and the ABAG Work Program is accurate.

3. The influence of Delta outflows on the quality of the Bay cannot be denied especially with regard to suspended solids. However, the characteristics of suspended solids from surface runoff are considerably different than those from the Delta. For example, suspended solids from urban areas are known to transport high concentrations of heavy metals, bacteria and other pollutants.

COUNTY: MARIN

SOURCE:

- Progress Report #4, "Examination of Existing Water Quality Problems in Marin County," February 28, 1977, 11 pp.
- Addendum to Progress Report #4, June 3, 1977, 5 pp.
- Progress Report #11, "Examination of Future Water Quality Problems in Marin County," June 3, 1977, 22 pp.

MAJOR FINDINGS:

1. Suspended solids appear to be the most serious surface runoff problem. The loadings of suspended solids from surface runoff exceed those from the sewage treatment plants. The point sources loads are insignificant by comparison. Although a certain amount of these suspended solids result from natural erosion of the rugged terrain of Marin County, man's activities increase this erosion many times. The sources are construction grading, road building, improper road drainage, and overgrazing of dairylands. The problem, to a large extent, is that the existing ordinances are not properly enforced.

2. The BOD in surface runoff is probably as serious a problem as that from sewage treatment plant discharges. This problem is partially attributed to leaves and other organic materials that are often raked or fall into gutters to be washed into streams or drainage channels. Also, the burning ban is increasing this method of disposal. Surface runoff probably also contributes a substantial percentage of the nitrogen entering the Bay from Marin County. Bacteriological contamination might also be a problem. However, no sufficient documentation is available. The sources are failing septic systems, runoff from dairies, horse and dog droppings. There is a possibility of a lead problem (and possibly other metals), but the limited data collected this year are insufficient to firmly establish a problem.

3. With the possible exception of BOD the changes in pollutant loadings from Marin County during the 1975 to 2000 investigation period do not appear to be significant. With the exception of erosion problems during construction, the present problems are also the future problems. This conclusion must be qualified based on the fact that Marin County's projections are 70% lower than ABAG's Series 3 projections for Marin.

ABAG STAFF
COMMENTS: Staff generally agrees with these major findings. It must be pointed out that should additional development increase as predicted by Series 3, the future surface runoff problems will be considerably greater than anticipated by Marin County. Also, staff is not in complete agreement with Marin regarding the sufficiency of problem documentation concerning bacteriological contamination from surface runoff. The frequent use of qualifiers such as "appear to be," "probably," "possibly" in describing the identified problems does not correspond to staff opinion

COUNTY: NAPA

SOURCE:

- Progress Report #6, "Examination of Existing Water Quality Problems in Napa County," February 28, 1977, 17 pp.
- Personal communication of modeling results regarding examination of future water quality problems.

MAJOR FINDINGS:

1. Suspended solids appear to be a problem related to surface runoff. Over 3 million pounds of soil are lost from Napa County each year in surface runoff. The seriousness of this problem has not yet been determined.

2. BOD loadings are presently 70% greater than point source contributions during the rainy six-month period. By 2000, it is anticipated that BOD loadings from surface runoff will be six times the loadings from treated point sources.

3. On a per-acre basis, developable sub-watersheds contribute the greatest amounts of suspended solid, nitrogen and phosphorus. Existing urban lands appear to contribute the greatest BOD load on a per-acre basis.

4. The types of problems shown by the pollutant loads do not appear to change significantly in the future.

5. Several water bodies within Napa county are believed to have problems caused by surface runoff.

6. The sources and nature of these problems will be addressed in greater detail in the continuing planning process.

ABAG STAFF COMMENTS:

Based on the modeling coefficients selected, the above findings are in agreement with staff analysis.

COUNTY: SAN MATEO

SOURCE:

- Progress Report #9, "Examination of Existing Water Quality Problems in San Mateo County," April 19, 1977, 82 pp.
- Progress Report #13, "Examination of Future Water Quality Problems in San Mateo County," June 7, 1977, 52 pp.

MAJOR FINDINGS:

1. The concentrations of lead in surface runoff are unacceptable and may present a threat to the aquatic environment.

2. The concentrations of suspended and volatile suspended solids in surface runoff are only marginally acceptable and may be causing a reduction in the quality of aquatic habitats.

3. Nutrients (Nitrogen and Phosphorus) and orgnaics (as represented by BOD_5) are not a problem in the waters of San Mateo County.

4. The identification of surface runoff water quality problems in San Mateo County is not yet complete and further analysis of the problem will be a part of the continuing planning process.

5. Debris in stream channels and catch basins is a major pollution problem in San Mateo County.

6. Infiltration from sewers along with pollutant accumulation on parking lots are other possible sources to be controlled.

7. Lagoons bordering San Francisco Bay show signs of water quality problems as exemplified by the severe algal blooms.

ABAG STAFF COMMENTS:

It is important to note that althrough San Mateo County joined the EMP six months late, substantial progress in all aspects of the work was made. In addition to the problem identification approach suggested by ABAG, San Mateo County also made an intial step at problem analysis through a somewhat objective approach. While staff disagrees with certain specifics of their supplemental methodology, it is hoped that they succeed in developing a useful tool for problem identification in the continuing planning process.

COUNTY: SANTA CLARA

SOURCE:

- Progress Report #8, "Examination of Existing Water Quality Problems in Santa Clara County," March 3, 1977 36 pp.
- Preliminary draft of potential problem constitutents existing in surface runoff (findings 6, 7 and 8 subject to revision based on final analysis).

MAJOR FINDINGS:

1. Siltation and debris accumulation in storm sewers and channels occurs in varying degrees over the entire county.

2. Grease, oil or floating scum exists in channels or in sloughs, mostly in urbanized areas.

3. High bacterial levels occur in streams and channels in various areas of the south county due to decomposed stock carcasses and garbage deposits.

4. Some septic tank leach fields are malfunctioning.

5. Mercury from mine tailings may be serious surface runoff pollutant. Several streams and reservoirs in the county are closed to fishing due to high levels of mercury in fish. The nature of the problem warrants monitoring of mercury in surface waters and sediment of the county.

6. With the exception of total suspended solids, the annual mass load for each pollutant increases during each time period from 1975 to 2000 for each sub-area category.

7. The major contribution of suspended solids comes from the open areas.

8. For BOD_5, total nitrogen and total phosphorus, the major annual mass load contribution comes from the urbanized areas.

ABAG STAFF COMMENTS: Staff is in agreement with the Santa Clara County findings.

COUNTY: SOLANO

SOURCE:

- Progress Report #7, "Examination of Existing Water Quality Problems in Solano County," February 28, 1977, 21 pp.
- Progress Report #14, "Examination of Existing and Future Stormwater Quality Problems in Solano County," June 10, 1977, 25 pp.

MAJOR FINDINGS:

1. Water quality problems in Solano County with surface runoff as a possible cause include:
   - low dissolved oxygen
   - coliform bacteria
   - pesticides
   - heavy metals

2. Surface runoff accounts for 90% of the suspended solids load to receiving waters.

3. In the more urban areas of Solano County, the point sources accounted for 75% of the BOD and nutrient loading.

4. In the rural areas, surface runoff accounted for almost all of the input of these constituents.

ABAG STAFF COMMENTS:

Staff is in general agreement with the findings of Solano County. Consideration should be made in the continuing planning process for further investigation of possible problems such as pesticides from surface runoff. Also, it is hoped that Solano County will make every effort to interface surface runoff problem analysis with the Suisun Marsh Plan being developed by the Bay Conservation and Development Commission.

COUNTY: SONOMA

SOURCE:

- Progress Report #5, "Examination of Existing and Future Stormwater Quality Problems in Sonoma County," June 3, 1977, 43 pp.
- Progress Report #10, "Examination of Existing and Future Stormwater Quality Problems in Sonoma County," June 3, 1977, 43 pp.

MAJOR FINDINGS:

Because the northern portion of the county is outside the study area, the following conclusions address only those problems found in the Petaluma River and Sonoma Creek Basins. These findings pertain only to the five MAC model pollutant parameters---BOD, SS, VSS, TN and TP.

1. Surface runoff represents the major source of water pollution in Sonoma County (except phosphorus) with the majority coming from open land.

2. Surface runoff loads in the two study basins are expected to increase significantly by the year 2000 as a result of future development. Best management practices should concentrate on controlling surface runoff from developing areas becasue of their high pollution loading rates (especially BOD).

3. Suspended solids loads from the Sonoma and Petaluma Basins are over 60,000 tons/year, far exceeding the loads of the other water quality constituents.

ABAG STAFF COMMENTS:

Staff agrees with these findings, but believes that best managment practices should be applied to all land uses based not only on pollution loading rates, but also on the multiple-use potential of Best Management Practices and cost/effectiveness considerations.

APPENDIX B

SUMMARY OF MONITORING DATA BY LAND USE

TABLE B - 1	CONCENTRATIONS FROM VIRGIN LAND
TABLE B - 2	ORGANICS
TABLE B - 3	SOLIDS
TABLE B - 4	NUTRIENTS
TABLE B - 5	BACTERIA
TABLE B - 6	HEAVY METALS
TABLE B - 7	OIL AND GREASE

SUMMARY OF MONITORING DATA BY LAND USE

The information presented in this Appendix attempts to summarize the most significant results of the monitoring program conducted this year (76-77) in the San Francisco Bay Area. Explanations regarding the selection of specific water quality parameters, sites monitored and other information regarding the monitoring program can be found in Progress Report #1, Summary of County Water Quality Sampling Program. Further detailed analysis of the sampling program results will be included in the upcoming staff report.

Tables B-2 through B-7 provide concentrations of various surface runoff pollutants measured this year . A certain perspective of the measured values can be gained by comparison with the concentrations for the same parameters for virgin lands. National data for virgin lands is given in Table B-1.

TABLE B - 1

SUMMARY OF BACKGROUND SURFACE RUNOFF CONCENTRATIONS FROM VIRGIN LAND[a]

Parameter	Concentration Range (mg/l)	Highest Concentrations	Lowest Concentrations
Nitrogen (inorganic)	0.05 - 0.50	Iowa, Illinois, Indiana	South, East & West Coasts
Phosphorus (total)	0.0 - 0.20	Iowa, Nebraska, Dakotas	South, East & West Coasts
BOD_5	0.50 - 3.0	Iowa, Illinois	South, East & West Coasts
Coliform (total)[b]	100 - 2,000	West of Mississippi	Northeast, Southwest
Sediment (SS)	2 - 100	Montana, South Dakota, Nebraska	East, West Coasts

[a]Source: EPA, 1976. Areawide Assessment Procedures Manual, Vol. I.
[b]Number/100 ml

The most characteristic feature of the data presented in Tables B-2 through B-7 is the tremendous variation in the quality of surface runoff. Nevertheless, some significant observations could be made as follows:

ORGANICS (BOD, COD) The average concentration of organic materials in stormwater runoff (TABLE B-2) is similar to effluent from secondary treatment plants (25 mg/l BOD). Peak concentrations of these materials may even approach those found in raw sewage (200 mg/l BOD)

In fresh water bodies and sheltered areas bordering San Francisco Bay, these pollutants may result in significant oxygen depletions.

TABLE B - 2

Flow Weighted Concentrations of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) from Individual Watersheds

	BOD (mg/l)			COD (mg/l)		
Land Use	Mean	Range	St. Dev.	Mean	Range	St. Dev.
Residential	21	7-40	9	159	94-195	42
Commercial	21	16-38	-	255	-	-
Industrial	22	7-38	14	113	104-119	11
Open & Agriculture	8	4-13	3	109	14-152	70
AVERAGE	18	4-40	9	140	14-195	41

SOLIDS (SS, VSS, TDS) The average amounts of suspended solids (370 mg/l) is considered moderate to high in the professional literature. Such concentrations (TABLE B-3) are normally believed to have a damaging effect on lakes and streams. The amount of solids in surface runoff will increase with larger storms. Therefore, the values of solids measured this year are probably conservative compared with an average rainfall year. It can be argued that the effect of these materials is not significant when compared with the volume of solids brought into the Bay through the Delta. However, the solids contained in stormwater runoff from urban areas contain larger quantities of metals, organic and bacterial pollutants.

TABLE B - 3

Flow Weighted Concentrations of Suspended Solids (SS), Volatile Suspended Solids (VSS) and Total Dissolved Solids (TDS) for Individual Watersheds.

	SS (mg/l)			VSS (mg/l)			TDS (mg/l)		
Land Use	Mean	Range	St. Dev.	Mean	Range	St. Dev.	Mean	Range	St. Dev.
Residential	252	81-557	221	26	19-98	26	176	42-1906	554
Commercial	158	-	-	69	-	-	-	-	-
Industrial	95	72-114	21	34	21-45	13	154	-	-
Open & Agri.	786	27-5200	1970	109	16-550	217	109	35-483	180
AVERAGE	370	72-5200	737	66	16-550	85	146	35-1906	367

NUTRIENTS (TN,TP) The amounts of nutrients entering regional lakes and streams are great enough to accelerate the process of eutrophication. The average concentration (TABLE B-4) of nitrogen (3.9 mg/l) and phosphorus (0.5 mg/l) are many times above the levels associated with stimulation of rapid growth of aquatic plants (algae). The amount of nutrients entering the Bay from surface runoff is much less than that entering from sewage treatment plants.

TABLE B - 4

Flow-Weighted Concentrations of Total Nitrogen (TN) and Total Phosphorus (TP) for Individual Watersheds

Land Use	TN Mean	TN Range	TN St. Dev.	TP Mean	TP Range	TP St. Dev.
Residential	3.8	1.2-7.1	1.9	0.5	0.02-0.9	0.24
Commercial	7.0	-	-	0.7	-	-
Industrial	3.6	1.3-4.5	2.9	0.3	0.2-0.4	0.1
Open & Agriculture	3.4	2.1-5.1	1.0	0.7	0.2-2.4	0.8
AVERAGE	3.9	1.2-7.1	1.9	0.5	0.02-2.4	0.4

BACTERIA (TC,FC,FS) The number of bacteria measured in surface runoff indicates significant amounts of fecal contamination is present in stormwater (TABLE B-5). In some cases, the values approached those for raw sewage. In almost all cases, bacteria levels exceeded standards established for point sources and beneficial uses.

TABLE B - 5

Counts of Most Probable Number (MPN) per One Hundred Milliliter of Sample of Total Coliforms (TC), Fecal Coliforms (FC) and Fecal Streptococci (FS)

Land Use	TC (MPN/100 ml) Mean	TC Range	TC St. Dev.	FC (MPN/100 ml) Mean	FC Range	FC St. Dev.	FS (MPN/100 ml) Mean	FS Range	FS St. Dev.
Residential	250,000	10-1,450,000	455,000	110,000	240-580,000	200,000	91,000	79,000-100,000	10,000
Commercial	≥24,000	--	--	≥ 2,400	--	--	--	--	--
Industrial	≥24,000	--	--	≥ 2,400	--	--	--		--
Open & Agriculture	14,000	8,400-1,450,000	70,000	6,200	2,500-24,000	9,900	2,400	--	--
RANGE	--	10-1,450,000	--	--	2,400-580,000	--	--	--	--

HEAVY METALS (Hg, Cu, Zn, Ag, Ni, As, Pb, Cd, Cr) Concentrations of lead, zinc and copper were quite high. Concentrations of mercury, silver, cadmium and chromium were usually much lower, often near detection limits. The levels of some of these metals (up to one mg/l) indicates that they may present a serious threat to marine and fresh water life in the San Francisco Bay Area. (See TABLE B-6)

TABLE B - 6

Flow Weighted Concentrations (in mg/l) of Selected Heavy Metals for Individual Watersheds

	LEAD			CADMIUM			CHROMIUM		
Land Use	Mean	Range	St. Dev.	Mean	Range	St. Dev.	Mean	Range	St. Dev.
Residential	0.61	0.08-1.5	0.42	0.01	0.001-0.02	0.008	0.02	0.01-0.03	
Commercial	0.85	--	--	--	--	--	--	--	--
Industrial	1.3	0.65-1.96	0.74	--	--	--	--	--	--
Open & Agriculture	0.15	0.03-0.23	0.09	0.007	--	--	0.007	--	--
AVERAGE	0.72	0.03-1.96	0.33	--	--	--	--	--	--

	SILVER			NICKEL			ARSENIC		
Land Use	Mean	Range	St. Dev.	Mean	Range	St. Dev.	Mean	Range	St. Dev.
Residential	0.005	--	--	0.09	0.01-0.11	--	0.21	0.002-1.1	--
Insufficient data for Commercial, Industrial, Open and Agriculture									

	MERCURY			COPPER			ZINC		
Land Use	Mean	Range	St. Dev.	Mean	Range	St. Dev.	Mean	Range	St. Dev.
Residential	0.01	0.001-1.0	0.5	0.15	0.005-0.45	0.19	0.58	0.01-1.17	0.44
Insufficient data for Commercial, Industrial, Open and Agriculture									

FLOATABLES (Oil, Grease, Litter) The volume of oil and grease entering San Francisco Bay from surface runoff is approximately one-half million gallons annually. No attempt was made to quantify the amount of litter in surface runoff. Observations during sampling indicate that large quantities of litter and oil (TALBE B-7) are discharged into the Bay with stormwater runoff.

TABLE B - 7

Flow Weighted Concentrations of Oil and Grease for Individual Watersheds (in mg/l)

Land Use	Oil and Grease		
	Mean	Range	St. Dev.
Residential	6	5-8.3	1.5
Commercial	28	--	--
Industrial	25	5-33	14
Open & Agriculture	--	--	--
AVERAGE	20	5-33	8

APPENDIX C

SOURCES OF SURFACE RUNOFF POLLUTANTS

- ORGANICS
- SOLIDS
- NUTRIENTS
- BACTERIA
- HEAVY METALS
- FLOATABLES

SOURCES OF SURFACE RUNOFF POLLUTANTS

The sources of surface runoff pollution are diffuse and difficult to quantify. A partial list of some of these sources and their associated pollutants are provided in TABLE C-1. It is apparent that most major activities on land have potential for impacting the quality of receiving waters. TABLE C-2 identifies specific industrial sources and their associated pollutants. Major industries located in the Bay Area and presented in this table include petroleum refining, canning industries, seafood processing and dairy products.

TABLE C-3 provides information as to the content of the various pollutants in frequently found materials. The impact of these materials on the quality of surface runoff is not necessarily proportional to the amount of pollutants provided from these sources, but the table does give some insight into the possible sources of some pollutants. The possible influence of the automobile on surface runoff quality is evident from this table.

The following sections indicate major sources of surface runoff pollution according to pollutant categories.

ORGANICS (BOD, COD)

Most of the organic materials in surface runoff are derived from natural processes --decay of plant and animal matter. In the urban areas, the organic material most commonly consists of decaying leaves and other vegetation which are washed from the streets. Other significant urban sources of organic material include pet excrements and petroleum products related to the use of automobiles. In rural areas, vegetation from streambanks and livestock excrement are the primary contributors of organic material.

SOLIDS (SS, VSS, TDS)

The most important solid is the suspended form when discussing nonpoint source pollution in the Bay Area. Suspended solids are readily observable in surface runoff as 'dirty water'. Existing urban areas, because of the large percentage of impervious surfaces, contributed only a relatively small amount of suspended solids directly. However, the large amount of surface runoff from urban areas results in such high velocity flows in these streams, that it causes extensive erosion of stream channels. Developing areas, those lands with some ongoing construction, are also major contributors of suspended solids. The surface runoff erosion from roads, homes and other sites may increase 2000 fold over natural levels during construction. The suspended solids load from rural areas is large. Practices which contribute to this problem are overgrazing, poor tillage practices, livestock in streams, erosion following fires and logging operations.

NUTRIENTS (TN, TP)

The sources of nutrients are closely related to the sources of organic materials and suspended solids. Many nutrients are released when organic materials are decomposed by microorganisms. Therefore, one usually finds high concentrations of nutrients when high concentrations of organics are also present. Similarily, nutrients and other materials are often bound to suspended solids.

BACTERIA (TC, FC, FS)

Bacteria in surface runoff are derived from three sources: soil, plants and animals. The plants and soil generally contribute something less than 1000 MPN/100 ml (Total Coliforms). In urban areas, the primary sources of fecal contamination are from pet excrement and sewage overflows into storm drains. The latter source is more common in older sections of cities where sewer lines are leaking, broken or of insufficient capacity. In low density residential areas, malfunctioning septic tanks and confined animals (especially horses) are major sources of bacteria. Livestock operations are the most significant sources of bacteria in rural lands, especially where animals gain direct access to streams.

HEAVY METALS (Pb, Hg, Cd, Ag, Cu, Zu, Cr, Ni, As)

The major single source of heavy metals in urban areas is the automobile. Lead is currently the single most abundant heavy metal in surface runoff. Most lead is derived from the combustion of gasoline with the additive, tetraethyl lead. Gradual phasing out of lead additives is expected to reduce this source over the next decade. The automobile, however, is a significant source of many other heavy metals. The tires, brake linings, and other parts deposit chromium , copper, nickel and zinc on road surfaces during normal operation.

In rural areas sources of heavy metals, besides automobile use, include pesticides which contain various metals. Mine wastes (tailings) from existing and non-operational mines are also major sources of heavy metals. The exposed ores are subject to leaching during storm events resulting in metals such as mercury being added to surface runoff.

FLOATABLES (Oil, Grease, Litter)

The most common source of oil and grease in surface runoff is from automobile operation. These materials accumulate on streets and parking lots until they are removed by surface runoff.

Litter has only one source--people.

TABLE C - 1

SUMMARY OF ACTIVITIES AND ASSOCIATED POLLUTANTS

SOURCE	ACTIVITY	POLLUTANTS: SEDIMENT	ORGANICS	NUTRIENTS	HEAVY METALS	PETROLEUM	FLOATABLES	BACTERIA	PESTICIDES	ALKALINITY	ACIDITY	SALTS	SILICA, SULFIDE	THERMAL POLLUTION	RADIOACTIVITY
CONSTRUCTION ACTIVITIES	Clearing, pest control	X		X	X				X						
	Grading	X				X			X						
	Facility Const.				X	X	X	X	X						
	Site Restoration	X		X											
HYDROLOGIC MODIFICATIONS	Channel Modifications	X												X	
	Impoundments	X	X		X								X	X	
	Dredging	X	X	X	X								X		
	Maintenance		X	X											
RESIDUAL WASTES	Wastewater Sludge			X	X			X							
	Septage Residual	X	X	X	X			X							
	Water Treatment Sludge	X	X		X			X							
	Muni. Refuse		X		X			X		X	X				
	Air Pollution Control Residuals									X					
	Ind. Sludge											X			
	Feedlot Manure	X	X	X	X			X							
	Mining Waste										X				
	Dredge Soil	X	X												
MINING	Exploration	X													
	Facility Const.	X						X							
	Extraction	X			X			X			X	X			/
	Processing	X			X			X			X	X			/
	Closure	X	X		X			X	X		X	X			/
AGRICULTURAL	Cultivation	X		X					X						
	Harvesting	X	X												
	Feedlots	X	X	X				X				X			
	Grazing	X	X	X				X	X						
SILVICULTURE	Access	X													
	Harvesting	X		X					X					X	
	Reforestation	X		X					X						
	Growing Practices			X					X						

Source: EPA, 1976. Areawide Assessment Procedures Manual, Vol. I.

TABLE C - 2

SOURCES OF POLLUTANTS FROM INDUSTRIAL ACTIVITIES*

INDUSTRY CATEGORY	BOD_5	TSS	pH	COLOR	COD	PHENOLS	OIL AND GREASE	SURFACTANTS	TOC	NH_3	SULFIDE	Cr TOTAL	Cr 6	ZINC	K. NITROGEN	FECAL COLIFORM	NO_3-N	ORGANIC N	T. PHOSPHORUS	FLUORIDE	HEAT	COPPER	ALUMINUM	CYANIDE	MANGANESE	NICKEL	ARSENIC	CHLORINE	IRON	LEAD	MERCURY	T. DISSOLVED SOLIDS
1. PULP, PAPER AND PAPERBOARDS	X	X	X	X																												
2. BUILDERS PAPER AND BOARD	X	X	X																													
3. TIMBER PRODUCTS	X	X	X		X	X	X																									
4. SOAP AND DETERGENTS	X	X	X		X		X	X																								
5. DAIRY PRODUCTS	X	X	X																													
6. ORGANIC CHEMICALS	X	X	X		X	X																										
7. PETROLEUM REFINING	X	X	X		X	X	X		X	X	X	X	X																			
8. LEATHER TANNING AND FISHING	X	X	X				X				X	X			X	X																
9. CANNED AND PRESERVED FRUITS AND VEGETABLES	X	X	X													X																
10. NONFERROUS METALS		X	X		X					X										X		X	X									
11. GRAIN MILLS	X	X	X																													
12. SUGAR PROCESSING	X	X	X													X					X											
13. FERTILIZERS		X	X				X			X							X	X	X	X												
14. ASBESTOS		X	X		X																											
15. MEAT PRODUCTS	X	X	X				X			X						X																
16. FERROALLOYS		X	X			X						X	X								X			X		X						
17. GLASS	X	X	X		X	X	X												X													
18. ELECTROPLATING		X	X									X	X	X								X		X		X						
19. PHOSPHATE MANUFACTURING		X	X																X	X							X					X
20. FEEDLOTS	X															X																
21. CEMENT MANUFACTURING		X	X																		X											X
22 RUBBER PROCESSING	X	X	X		X		X																									
23 PLASTICS AND SYNTHETICS	X	X	X		X	X						X		X																		
24 INORGANIC CHEMICALS		X	X		X				X			X	X							X				X					X	X	X	
25. IRON AND STEEL		X	X			X	X			X				X			X			X			X		X						X	
26. TEXTILES	X	X	X	X	X	X	X					X				X																
27 STEAM ELECTRIC GENERATING EQUIPMENT		X	X				X														X	X						X	X			
28. SEAFOOD PROCESSING	X	X	X				X																									
TOTALS:	18	27	27	2	11	8	12	1	2	5	2	7	4	3	1	6	2	1	3	5	4	3	2	3	1	2	1	1	2	1	2	2

Source: EPA, 1976. Areawide Assessment Procedures Manual, Vol. I.

TABLE C - 3 SOURCES OF POLLUTANTS*

Material	Tot. Vol. Solids mg/g	BOD[a] mg/g	COD mg/g	Grease mg/g	Petroleum mg/g	n-Paraffins mg/g
oline	1000	150	680	1.3	1.3	1.3
ricating Grease	970	140		750	670	570
or Oil	1000	140	220	990	940	850
nsmission Fluid	1000	100	200	990	940	880
ifreeze	990	38	1100	140	70	6.1
ercoating	1000	90	310	960	180	120
halt Pavement	64	1.2	86	21	15	9
crete	71	1.4	64	2.7	1.3	1
ber	990	27	2000	190	100	56
sel Fuel	1000	80	400	390	310	210
ke Linings	290	17	420	31	8.3	7.6
ke Fluid	1000	26	2400	880	33	19
arettes	860	85	780	30	21	2.7
t[b]	75	-		0	0.0	0.0
ders	0.0	-	59	1.3	1.2	1.2
	-	-		-	-	-

Material	Lead	Mercury	Chromium	Copper	Nickel	Zinc
			Metals Content (ug/g)			
oline	660	0.05	15	4	10	10
ricating Grease	2	0.05	2	1	1	160
or Oil	9	0.05	2	3	17	1100
nsmission Fluid	8	0.05	2	1	21	240
ifreeze	6	0.05	2	76	16	14
ercoating	120	0.05	2	1	480	110
halt Pavement	100	0.05	360	50	1200	160
crete	450	0.05	93	99	260	420
ber	1100	0.05	180	250	170	620
sel Fuel	12	0.05	15	8	8	12
ke Linings	1100	0.05	2200	31,000	7500	120
ke Fluid	7	0.05	19	5	31	15
arettes	490	0.05	71	720	190	560
t	2	0.05	2	2	9	1
ders	2	0.05	2	3	4	7
Soil	2	0.05	36	23	25	27
ection Limit	2	0.05	2	1	1	0.01

haheen, 1975, "Contribution of Urban Usage", EPA 60012-75-004.

OD determinations were made on "pure" materials using a seed of unacclimated ewage organisms.

esults are on a dry weight basis. Salt as received contained 3.7% water, assayed 3.2% sodium chloride, and contained less than 0.005% cyanide.

APPENDIX D

REPORT ON PROGRAM PROGRESS, PROBLEMS AND ADVISORY COMMITTEE ACTIVITIES

The first brief included detailed description of program progress and problems. Considering the upcoming deadline of August 31 for county work completion, these aspects of the program are of diminishing importance. Nevertheless the following three sections are included here for sake of consistency with the first brief and as a record for future reference.

PROGRAM PROGRESS

Considerable work progress has been made during the last five months. This progress has been characterized by resolution of many of the program problems identified in the last brief (February 2, 1977). In particular, the following should be emphasized:

- late start of activities by some of the counties is not hindering work progress anymore. San Mateo County was particularly effective in making up for the lost time.

- execution of tasks and their transmittal to ABAG has significantly improved since last brief. Counties are showing a positive initiative in preparation of their surface runoff plans. The counties that selected consultant's services are not totally relying on consultant's work as it was appearing initially.

Resolution of other problems mentioned in the last brief as well as other program progress items are specified below:

1. <u>Monitoring Program Brought to a Successful Completion</u>

Although no adequate information is presently available for comparison, it appears that despite the drought this program is the largest one conducted by any of the 208 Planning Agencies west of the Mississippi, and possibly nationwide. The major attributes are: careful design, personnel training, and dedicated involvement of local agencies. Altogether 55 storm events were sampled in 22 watersheds.

The completion of the monitoring program was marked by execution of another workshop (May 18). This was Workshop #8 - Summary and Discussion of Monitoring Program Results. A draft summary report was discussed along with the monitoring needs and program modifications for the next year.

2. <u>Near Completion of the Modeling Program</u>

According to the original schedule the MAC modeling analysis was to have been completed at the end of April. However, because of various delays discussed under "Program Problems" the latest and presumably final runs of the MAC model were not completed and submitted to ABAG until early June. Thus, there was not sufficient time to review and refine each county analysis to assume regional consistency of assumptions. There is therefore some possibility that a limited number of additional MAC model runs may be needed.

In general, despite some delays in execution of individual tasks, the modeling effort proceeded well. The counties and ABAG staff effort over the last five months is marked by:

- conversion of Series 3 land use projection from 440 zones to MAC sub-watersheds
- review of Series 3 data by counties
- calibration of SWMM models for 12 watersheds
- adjustment of MAC model coefficients using local data
- running MAC model using 1975, 1985 and 2000 land use data

At present both the MAC and SWMM models are available and set-up on ABAG computers for assessing the control measures alternatives. Most counties are capable of independently using models as a tool in plan formulation. The technical aspects of the model and modeling program set-up are discussed in the Progress Report #2, "Summary of Surface Runoff Modeling Program," February 28, 1977.

3. Completion of First Set of County Progress Reports

The first set of county progress reports summarized the county work in examination of existing water quality problems. Seven progress reports were submitted to ABAG as follows:

- February 28, 1977 - Alameda County
- February 28, 1977 - Marin County
- February 28, 1977 - Sonoma County
- February 28, 1977 - Napa County
- March 2, 1977 - Santa Clara County
- April 19, 1977 - San Mateo County

4. Completion of Second Set of County Progress Reports

The second set of county progress reports summarized the county work on examination of future water quality problems, and in most cases provided an update to the first set of progress reports. Seven progress reports were submitted to ABAG as follows:

- June 1, 1977 - Sonoma County
- June 6, 1977 - Marin County
- June 7, 1977 - Alameda County
- June 7, 1977 - San Mateo County
- June 11, 1977- Solano County
- June 13, 1977- Contra Costa County (technical portion only)
- June 15, 1977- Santa Clara County (preliminary draft)

5. <u>Development of Background Information about Surface Runoff Control Measures</u>

This work is done jointly by ABAG, Woodward-Clyde Consultants and Bay Area Council Resource Conservation District (contracts executed in 3/25/77 and 4/15/77 respectively). For each contract measure a 2-4 page description was prepared emahasizing the following:

- brief technical description
- applicability and implementation requirements
- potential environmental and socio-economic impacts
- cost considerations
- evaluation of effectiveness
- references and examples of implementation

The work on urban control measures is essentially completed in a handbook, "Candidate Measures for the Control of Urban Runoff" draft of which was distributed at the second workshop on control measures: Workshop #7 - Development of Data Base for Surface Runoff Control Measures, May 4, 1977. The work on the open and agricultural lands control measures will be completed by July 7, 1977.

6. <u>Transfer of Technical Information</u>

a. Technical Memoranda:

- February 18, 1977 - Technical Memoramdum #5, "Guidance For Identification of Surface Runoff Pollution Problems."
- February 23, 1977 - Technical Memorandum #6, "Rainwater Quality and its Implications on Surface Runoff."
- April 4, 1977 - Technical Memorandum #7, "Guidance for Identification and Ranking of Surface Runoff Pollution Problems."

b. Progress Report:

- February 28, 1977 - Progress Report #2, "Summary of Surface Runoff Modeling Program."

c. Technical Workshops:

- Workshop #7 - Development of Data Base for Surface Runoff Control Measures (May 4, 1977).
- Workshop #8 - Summary and Discussion of Monitoring Program Results (May 18, 1977).

d. Other:

- May 4, 1977 - Surface Runoff Assessment Procedures Manual (prepared by the Assessment Evaluation Program staff).

- June 6, 1977 - Institutional Financial Manual for 13 Selected Surface Runoff Control Measures (prepared by Sedway-Cooke Consultants)

- June 7, 1977 - Manual of Candidate Measures from the Control of Urban Runoff (prepared jointly by Woodward-Clyde Consultants and ABAG staff)

7. Assistance to the Counties in Formulating Control Measures Alternatives

This will be the most crucial task in development of county plans. In anticipation of this task a "brainstorming" meeting was organized by ABAG on June 7, 1977. Specific county needs were identified. In particular a set of "plan formulation" meetings were scheduled with all of the counties. Participants in the meetings will be county and ABAG staff, Woodward-Clyde Consultants, local RCD's, and representatives of local public works and health departments, along with other local interest groups.

8. Identification of Funding for Initial Implementation of Surface Runoff Program

Staff is discussing with EPA Region IX the appropriateness of applying for these research and development funds.

- Continuation of monitoring program for the 1977/78 rainy season.

  Staff established informal contacts with the EPA National Environmental Research Center in Cinncinnati, and with the Office of Monitoring and Technical Support, EPA Research and Development Division.

- Establishing several demonstration projects of various surface runoff control measures

  Informal contacts with the EPA Nonpoint Source Branch, Office of Water Planning Division revealed that funds might be available for such demonstration projects (25 percent local participation).

- Further refinement of analytical tools

  A formal proposal "Stormwater Pollution Analysis with MAC Model for Continuing Planning of 208 Program" ($180,000) was submitted to the Storm and Combined Sewer Section of the EPA Municipal Environmental Research Laboratory in Edison, New Jersey. The proposal received positive EPA review but funding is pending on availability of funds.

PROGRAM PROBLEMS

Since the last brief (February 2, 1977) a number of problems have been encountered in the progress of the Surface Runoff Management Program. The overall effect of these problems was a two month delay in completing the analysis of the existing and future problems caused by surface runoff. Nevertheless, it is expected that the August 31 and October 12 deadlines for completion of county plans will be met by all counties. Some of the specific program problems are discussed below:

1. Delivery of projections data to counties was delayed.

This delay contributed to the push back of the final computer runs by about two months. There were several reasons for this delay. Series 3 projections by 440 zones, originally scheduled for Jan. 15, 1977, were not released until March 2, 1977. These did not contain year 2000 projections because the local policy survey estimates of available land and density were too low to accommodate growth beyond 1990. The year 2000 projection was not available until the end of April. The conversion of Series 3 land use data from 440 zones to MAC watersheds took longer than expected. Point source projections for 1985 and 2000 were also slow in coming. In short, whatever possibly could go wrong, went wrong.

2. Water quality and quantity data became available for model calibration very late.

Lack of rain, particularly from October through January, made an early start on model calibration impossible. The commercial laboratory was slow in completing its analysis of stormwater samples and in their submittal to ABAG and the counties. U S G S and the counties were slow in delivering historical streamflow records to the modeling consultants.

3. Execution of tasks and transmittal of information to ABAG by counties was generally slow.

Several counties took a considerable amount of time to review Series 3 land use data which was converted to MAC watersheds. Some of this delay was due to their initial reluctance to use Series 3 until the reveiw process is completed. Only five counties met the deadline for the progress report, "Examination of Existing Water Quality Problems." In ABAG staff opinion, most of these reports contained an inadequate amount of analysis of pollution problems and their causes. Only one county met the deadline for the progress report, "Examination of Future Water Quality Problems."

Some county staffs required a considerable amount of assistance from ABAG in using the computer facilities required to run the MAC model. This presented a considerable drain on ABAG staff time resources. Part of the problem can be attributed to inefficiencies in the Lawrence Berkeley

Laboratory computer system. It is a difficult system to learn and was extremely busy during working hours, causing frequent delays in it use. On June 1st, it became unavailable to everyone except ERDA users between 10 a.m. and 6 p.m.

4. <u>Execution of tasks by modeling consultants was slow.</u>

Calibration of the mathematical models was delayed as a result of problems with the automatic calibration algorithm and because of late delivery to the consultants of flow and quality data.

5. <u>Information on control measures was delayed.</u>

The development of background information about surface runoff control measures, originally scheduled for December 1976 - February 1977, was delayed by approximately four months. The primary cause for this delay was the slow execution of the contract with Woodward Clyde Consultants and with the Bay Area Council of Resource Conservation Districts.

6. <u>Massive effort needed to meet August 31 deadline for completion of county plans.</u>

A great deal must be accomplished over the next three months, especially in control measure analysis and intra-county review of county plans. Because of the above-mentioned delays, time must now be made up in order to meet the August 31 deadline. Despite the delays it is expected that all counties will meet this deadline.

7. <u>Funds not yet available to continue the monitoring program during the 1977-78 rainy season.</u>

This problem was also mentioned in the last brief. ABAG staff is exploring sources of potential funds. The problem is that the continuing planning process and the funds that will be probably avaiable for this purpose will describe the monitoring needs for the year 1978-79 and thereafter. Currently, however, no specific budget is available for the upcoming year 1977-78, which is formally part of the two-year planning period, yet the collected data can be useful only for the continuing planning process.

ADVISORY COMMITTEE COMMENTS AND STAFF RESPONSES

Since the last brief the Surface Runoff and Miscellaneous Sources Management Plans Committee has met three times. In addition, there were two meetings of the Coordination Group (county personnel) only.

Comments made by the advisory committee at these meetings are summarized in Table D-1. All these meetings were marked by very active participation of the county personnel and very often a declining involvement of the other committee members. The average participation in these meetings was 35 .

The committee meetings and major topics for discussion are listed below:

Meeting Date	Major Topic
March 3	County Work Progress and Problems
March 24................	Various Work Items Related to the Examination of Existing and Future Water Quality Problems (meeting of Coordination Group only).
April 28................	Review of a Draft Surface Runoff Brief #2
June 1..................	Meeting devoted exclusively to the Miscellaneous Pollution Management Program*
June 7..................	Formulation of Control Measures Alternatives (meeting of Coordination Group only).
June 17.................	Review of the Surface Runoff Brief #2 (joint meeting with the Special Studies Technical Advisory Committee).

* comments not included in Table D-1

TABLE D - 1

ADVISORY COMMITTEE COMMENTS AND STAFF RESPONSES

	COMMITTEE COMMENTS	STAFF RESPONSES
Meeting of March 3, 1977	1. Counties need more discussion of existing problems and control measures	1. An additional coordination group meeting will be scheduled to discuss these topics.
	2. Lack of monitoring data is making model calibration difficult and will make control measures hard to justify.	2. Data from this year is not essential for model calibration. Historical data can be used. Models are used to simulate situations where a complete informational base is lacking.
	3. Format provided by ABAG for county progress reports was quite helpful. Request ABAG supply counties with format for county final reports.	3. Thanks. Staff will prepare format at a later date.
Meeting of March 24, 1977	Coordination Group 1. Will Series 3 Projections be used for MAC modeling prior to final review and approval?	1. The schedule for Series 3 reviews makes it impossible to use the final figures, since review will not be completed until summer. The final projections are not expected to be significantly different than the ones available now. If there are significant changes in some areas, additional MAC runs can be made.
	2. Will the counties be given information by April 28 on the reduction in pollutant loads resulting from each control measure?	2. By April 28 counties will have workbooks containing 2-page descriptions of each control measure. Some information on reduction will be available, but not all the answers.
	3. Counties will probably not be able to use SWMM model for control measure evaluation until May and there would be no real plan formulation until July.	3. Staff agrees that SWMM will not be calibrated until May, but feels that plan formulation must begin in June.
Meeting of April 28, 1977	Coordination Group 1. ABAG should distribute the results of this year's sampling program prior to the discussion of this information at the next meeting.	1. Agreed.
	2. Further sampling is needed next year.	2. Agreed. Counties should submit to ABAG descriptions of what streams and parameters they would like to monitor next season.
	3. Counties need about six weeks for local review of their county plans before they can submit them to ABAG. Under the present August 31 deadline for plan submittal, this would require plans near completion by July 15	3. After considerable debate during which staff emphasized that the schedule for EMP preparation is very tight (under Federal law) and cannot tolerate much slippage, staff agreed to discuss this issue at the next lead agency meeting.
	4. The national coefficients for suspended solids runoff from open land greatly underestimate the actual runoff loads.	4. The national open land coefficients were based on open land within cities. These figures will soon be revised using the locally collected sampling data.

	COMMITTEE COMMENTS	STAFF RESPONSES
Meeting of April 28, 1977 (continued)	Advisory Group	
	5. What is the viability of the "do-nothing" alternatives?	5. Response of EPA representative: This alternative is allowed in all EISs, but EPA is not looking forward to it coming out of the 208 programs.
	6. County staff made considerable comments on Surface Runoff Brief No. 2: Conclusions are premature; the regionality of the problem has not been substantiated by the study so far; more time is needed for review and comment within the counties; the amounts of pollutants from surface runoff are significant but need to further assess whether there is a problem; regional regulation is a hot issue on the local level; Surface Runoff Brief No. 2 should not be released to the EMTF at this time.	6. Staff is willing to qualify the results and include statements from each county expressing their reservations. If the program identifies regional problems, the State and the EPA will probably not be willing to accept a plan of voluntary action by local governments. Results to date are preliminary, but the analysis does suggest that there are problems. Staff, however, agrees not to release Brief No. 2 until there is further analysis and discussion with the committee.
Meeting of June 7. 1977	Coordination Group only	
	1. Some cities are giving pollution clean-up a low priority; they are cutting back on their budgets for items like street sweeping.	1. In the context of EMP the cities may be willing to reevaluate their priorities.
	2. There still is a need to better define pollution problems.	2. Agree. However, the information obtained so far is sufficient for initial planning. Further problem analysis will be done as part of the continuing planning process.
	3. Counties are leaning towards developing Surface Runoff Plans consisting of recommendations on how to make exisitng control practices more effective. Practices cited included: a. Street-sweeping cooperation among cities b. Litter control c. Envorcement of exisitng erosion and grading ordinances d. Rangeland management e. Public eduction	3. This is a good start. As part of plan development a more rigerous examination of all surface runoff control measures will be carried out.
	4. Counties need more information on impacts of surface runoff on the Bay and the cost effectiveness of different control measures.	4. Agree. Staff is aware of these needs. Information will be provided to the counties as it becomes available.
	5. Counties would like to share information on existing control practices, institutional arrangements and finances.	5. Staff will facilitate such information exchange through additional meetings of the coordination group, and through a complete round of meetings with individual counties.

TABLE D - 1 (continued)

	COMMITTEE COMMENTS	STAFF RESPONSE
Meeting of June 17, 1977 (Joint Meeting with Special Studies TAC)	1. Environmental carcinogens are the most serious toxicant problem in the Bay.	1. This is an opinion of a consultant to ABAG on Special Studies
	2. Fish kills have been increasing since 1969. The number of killings from unknown causes is also increasing.	2. This is a Special Studies report.
	3. Bacterial levels in the Bay are decreasing, but very few areas are unconditionally approved for shellfish harvesting at present.	3. Same as above.
	4. County personnel expressed considerable concern about the issue of regional enforcement of surface runoff control measures. Points raised included: a. It is too early to bring up regional issue b. It will be difficutl to get the local governments to pay of rpollution clean-up if problems have not been definitively identified. c. ABAG should make clear the objectives of the probram, such as emphasis on control measures with low cost.	4. Regional enforcement may or may not be part of the plan. However, it is necessary to raise this issue for discussion at this time. It will probably never be possible to conclusively define the problems and their causes to everybody's satisfaction. However, the evidence available today suggests that surface runoff problems cannot be ignored, and that sufficient information exist to justify some low cost, non-structural remedial action. Actions taken should be appropriate to our level of understanding of the problem.
	5. The brief should point out the multi-purpose benefits of control measures.	5. This point has been empahsized all along. However, it is not appropriate for this brief which addresses pollution problems, rather than the problem of mitigation.
	6. Will the EMP deal with the impact of human and mechanical failures, such as treatment plant break-down and strikes.	6. The EMP will contain a small section on contingencies to deal with this issue.

APPENDIX E

GLOSSARY OF TECHNICAL TERMS

Algae	Any of numerous chlorophyll-containing plants of the phylum thallophyta that grow in either sea water or fresh water; seaweeds and pond scum are algae.
Ag	Silver
Ambient	Completely surrounding or encompassing.
Ar	Arsenic
Bacteria	A single-celled micro-organism without a nuclear membrane capable of sexual reproduction.
Base Flow	Stream discharge derived from groundwater sources. Sometimes considered to include flows from regulated lakes or reservoirs. Fluctuates much less than storm runoff.
BOD_5	Five-day Biochemical Oxygen Demand: A standard test for the amount of oxygen utilized in aerobic decomposition of a waste material during a five-day incubation at a specified constant temperature.
Ca	Cadmium
Calibration	The procedure of assigning values to the uncertain or unknown parameters in simulation model and adjusting them until model predictions correspond acceptably with observed prototype behavior.
Catch Basin	A chamber or well, usually built at the curb line of a street, for the admission of surface water to a sewer or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.
Cr	Chromium
Cu	Copper
Concentration	The quantity of a given constituent in a unit volume or weight of water.
Dissolved Solids	The total amount of dissolved material, organic and inorganic, contained in solution in water or wastes.
D.O.	Dissolved oxygen, the amount of gaseous oxygen dissolved in a liquid sample.
Drainage Basin	A geographical area or region which is so sloped and contoured that surface runoff from streams and other natural watercourses is carried away in a single drainage system by gravity to a common outlet or outlets; also referred to as a watershed or drainage area.

Dry Weather Flow — The combination of sanitary sewage, and industrial and commercial wastes normally found in the sanitary sewers during the dry weather season of the year. Also, that combination of flow in streams during dry seasons.

Eutrophication — The progressive enrichment of surface waters particularly non-flowing bodies of water such as lakes and ponds with dissolved nutrients, such as phosphorous and nitrogen compounds, which accelerate the growth of algae and higher forms of plant life and result in the utilization of the useable oxygen content of the waters at the expense of other aquatic life forms.

Fecal Coliform — Fecal coliform are indicators of human and animal pollution and are expressed as numbers of bacteria per volume of sample.

First Flush — The condition, often occurring in storm sewer discharges and combined sewer overflows, in which a disproportionately high pollution load is carried in the first portion of the discharge or overflow.

Floatables — Litter, debris, oil and grease

Heavy Metals — Metallic elements with high molecular weights, generally toxic in low concentrations to plant and animal life. Examples are: mercury, chromium, cadmium, arsenic and lead.

Hg — Mercury

Hydrograph — A flow versus time graph derived from direct measurement of runoff.

Loading — The dry weight, in pounds, of some material that is being added to a process or disposed.

Ni — Nickel

Nitrate (NO_3) — A form of nitrogen which is an essential nutrient to plants (can cause algal blooms if all other nutrients are present in sufficient quantities). Product of bacteria oxidation of other forms of nitrogen, from the atmosphere during electrical storms and from fertilizer manufacturing.

Nitrogen — Usually ammonium, nitrite, and nitrate ions, and certain simple amines are available for plant growth. A small fraction of organic or total nitrogen in the soil is available at any time.

Nonpoint Source Pollution — A pollutant which enters a water body from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.

Nutrients	Substances essential to biological growth.
Organics	Materials composed of carbon, hydrogen and oxygen (CH_2O).
Overflow	A pipe line or conduit device together with an outlet pipe that provides for the discharge of portions of combined sewer flows into receiving waters or other points of disposal, after a regulator device has allowed the portion of the flow which can be handled by interceptor sewer lines and pumping and treatment facilities to be carried by and to such water pollution control structures.
Outfall	The point, location, or structure where wastewater or drainage discharges from a sewer to a receiving body of water.
Pb	Lead
Point Source Pollution	"The term 'point source' means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation vessel or other floating craft, from which pollutants are or may be discharged." (Act, Section 502(14)).
Pollutant	"The term 'pollutant' means dredged spoil, solid waste, incincerator residue, sewage, garbage, sewage sludge, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water." (Act, Section 502 (6)).
Pollutograph	A graph of pollutant concentration as a function of time during a rainfall/runoff event.
PCB	Polychlorinated Biphenyls. Organochlorine compounds of a pesticidal nature which are usually used for industrial purposes (such as plastic manufacture).
Residual Wastes	Those solid, liquid, or sludge substances from man's activities in the urban, agricultural, mining and industrial environment which are not discharged to water after collection and necessary treatment.
Runoff	That portion of the precipitation on a drainage area that is discharged from the area in stream channels.
Runoff Coefficients	Fraction of rainfall that appears as runoff after subtracting depression storage and interception. Typically accounts for infiltration into ground and evaporation.

Sedimentation	The process of subsidence and deposition of suspended matter carried by water, sewage, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point where it can transport the suspended material.
Surface Runoff	Precipitation that falls onto the surfaces of roofs, streets, ground, etc., and is not absorbed or retained by that surface, thereby collecting and running off.
TDS	Total Dissolved Solids. The dissolved salt loading in surface and subsurface waters.
Watershed	The region drained by or contributing water to a stream, lake, or other body of water.
Wet Weather Flow	A combination of dry weather flows, infiltration, and inflow which occurs as a result of rainstorms.
Zero Pollution	A degree of pollution control or prevention which eliminates the addition of any contaminants or unwanted foreign material into surface water sources; incorrectly interpreted as "zero discharge" of any effluents into water courses (land application of wastewater effluents has been suggested as one means of establishing "zero pollution" conditions).

SURFACE RUNOFF MANAGEMENT PLAN

ORGANIZATIONAL STRUCTURE OF THE SURFACE RUNOFF MANAGEMENT PROGRAM

ISSUE PAPER NO. 1
NOVEMBER 30, 1976

A. INTRODUCTION

The purposes of this issue paper are to describe:

(1) The functional organization of the Surface Runoff Management Program (SRMP)

(2) How this program fits into the overall structure of the Environmental Management Plan (EMP), and

(3) The procedures for work coordination.

This SRMP will produce a plan for the management of surface runoff that will address the following:

- o Severity of the pollution problem in the San Francisco Bay Area
- o The need for adequate water quality data
- o The need for adequate technical information about surface runoff control measures, their effectiveness and cost.
- o Fiscal effect of the proposed plan on implementing agencies
- o Benefits to be achieved

The Surface Runoff Management Plan will emphasize near-term, non-structural solutions to the existing problems. It will consist of control measures and institutional financial mechanisms to carry them out. It will also include a description of the continuing planning process. This plan will be integrated with six other management plans to make up the EMP. The other six plans are:

- o Air Quality Maintenance
- o Municipal Wastewater Facilities
- o Industrial Dischargers
- o Minor Sources
- o Water Conservation, Supply and Reuse
- o Solid Waste.

A description of all these plans is contained in the summary of the ABAG 208 Work Program.

This Issue Paper is divided into the following sections:

- o A description of the structure of the Surface Runoff Management Program
- o A description of the overall structure of the EMP
- o Descriptions of the structures of the eight county surface runoff programs
- o A description of the structure within ABAG for the surface runoff program, including consultants to ABAG
- o A description of the Surface Runoff and Minor Sources Management Plans Committee
- o Brief biographical sketches of staff and committee members involved in the preparation of the Surface Runoff Management Plans.

B. STRUCTURE OF THE OVERALL SURFACE RUNOFF MANAGEMENT PROGRAM

The functional organization chart of the SRMP is shown in Figure 1. The key to the future of this program is the fact that local governments are involved in plan development. Table 1 lists the county agencies responsible for development of the county surface runoff management plans and the budgets available to them. ABAG is transferring more than $1 million dollars to the counties for plan development. These funds are also intended to pay for meetings, seminars, workshops and public discussions which will insure a consistent and uniform planning process. In addition to the county budgets, ABAG will provide a number of services to the counties to insure the quality and consistency of the work:

1. Mathematical modeling of surface water runoff

FIGURE 1

ORGANIZATION OF THE SURFACE RUNOFF MANAGEMENT PROGRAM

COUNTIES	SURFACE RUNOFF PROJECT DIRECTOR/PROJECT MANAGER	RUNOFF SUPPORTING STAFF	RUNOFF LIASON
ALAMEDA (COUNTY)	ROLAND MAYNE/ JACK LINDLEY	GARY SHAWLEY, JERRY KILLINGSTAD, KEN FUJIMOTO, COLIN KESTERSON, TOM THOMPSON, RICK BAKER, JEFF MORRISON, WOODWARD/CLYDE (CONSULTANTS)	STEVE GOLDMAN (ABAG); ROBERT FINN (M&E)
ALAMEDA (CORPS OF ENGINEERS)	WAYNE OLSEN		
CONTRA COSTA	VERNON CLINE	J.E. TAYLOR, MILTON KUBICEK, BOYD JEWETT, OLIVER SMITH, BAOLIN WU, LOU HURLEY	STEVE GOLDMAN (ABAG); GEORGE OTTE (M&E)
MARIN	MARK RIESENFELD/ CHARLES MURPHY	JOHN WOOLEY, STEVE MAKI, DOLORIS LYON	MARCINE MARTIN (ABAG); ROBERT FINN (M&E)
NAPA	JACK WARREN/ BERNARD KLEIN	DAVID BABITZ, HERB KNIERM, LARRY WILEY, WILLIAM McCORMICK	STEVE GOLDMAN (ABAG); WILLIAM NORTON (RMA)
SAN MATEO	NEIL CULLEN	BARRY NATHAN	MARCINE MARTIN (ABAG); GEORGE OTTE (M&E)
SANTA CLARA	ROBERT STURDIVANT/ DAVE GILL	GENE WATSON, ABDULLAH SAAH, [illegible] GLOEGE, CONSULTANTS: METCALF & EDDY INC	JOSEPH EILERS (ABAG); GEORGE OTTE (M&E)
SOLANO	CLAYNE MUNK/ JOHN SWENSON	GENE KNAPP, [illegible] GRAY, PETER LYNCH, CONSULTANTS: WATER RESOURCES ENGINEERS, INC. JAMES M MONTGOMERY CONSULTING ENGRS	JOSEPH EILERS (ABAG); ROBERT FINN (M&E)
SONOMA	WILLIAM STILLMAN / RODERICK [illegible]	STEVE MANNVIELER, JAMES FRANKLIN, BRUCE [illegible], LOUIS VAN [illegible]KVIELE	STEVE GOLDMAN (ABAG); DENNIS McLAUGHLIN (RMA)

SURFACE RUNOFF MANAGEMENT PLAN

PROGRAM MANAGER: YORAM LITWIN

TASK LEADERS:

SITE SPECIFIC ANALYSIS & ASSISTANT PROGRAM MANAGER: STEVE GOLDMAN

MACROSCOPIC PLANNING: MARCINE MARTIN

MONITORING: JOSEPH EILERS

COORDINATION WITH ABAG SUPPORTING SERVICES: ROBERT FROMMER

SUPPORTING STAFF: JOHN SHAFFER, FREDRICK WOLIN

SURFACE RUNOFF MODELING CONSULTANTS

(METCALF & EDDY / RESOURCE MGMT ASSOCIATES)

PROJECT MANAGEMENT
- JOHN LAGER (M&E)
- GERALD ORLOB (RMA)
- WILLIAM SMITH (M&E)

SUPPORTING STAFF
- DENNIS McLAUGHLIN (RMA)
- WILLIAM NORTON (RMA)
- GEORGE OTTE (M&E)
- ROBERT FINN (M&E)

SURFACE RUNOFF & MINOR POLLUTION SOURCES MANAGEMENT PLANS COMMITTEE

COMMITTEE CHAIRMEN
- YORAM LITWIN/ B J MILLER

PARTICIPATION
- COUNTY AGENCIES
- REGIONAL AGENCIES
- STATE AGENCIES
- FEDERAL AGENCIES
- PUBLIC & SPECIAL INTEREST GROUPS

SEE FIGURE 2

TABLE 1

COUNTY RESPONSIBILITIES AND BUDGETS FOR EMP PROGRAMS

COUNTIES	CONTRACTING BODY	AGENCY OR DEPARTMENT RESPONSIBLE FOR:				TOTALS
		SURFACE RUNOFF MANAGEMENT PLAN	BUDGET	LOCAL POLICY SURVEY & PUBLIC PARTICIPATION PROG.	BUDGET	
ALAMEDA	ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT (ACFCWCD)	ACFCWCD[1]	146,859			169,191
	COUNTY			PLANNING	22,332	
CONTRA COSTA	COUNTY[2]	PUBLIC WORKS	91,000			120,000
				PLANNING	29,000	
MARIN	COUNTY	PUBLIC WORKS	79,586			99,160
				PLANNING	19,574	
NAPA	COUNTY	PUBLIC WORKS	80,900			99,000
				PUBLIC WORKS	18,100	
SAN FRANCISCO					29,000[3]	29,000
SAN MATEO	COUNTY	PUBLIC WORKS	121,600			141,000
				PLANNING	19,400	
SANTA CLARA	SANTA CLARA VALLEY WATER DISTRICT (SCVWD)	SCVWD	130,000			170,000
	COUNTY			PLANNING	40,000	
SOLANO	COUNTY	PUBLIC WORKS	35,600			58,000
				PLANNING	22,400	
SONOMA	SONOMA COUNTY WATER AGENCY (SCWA)	SCWA	62,600			85,000
				SCWA	22,400	
BUDGET TOTALS			748,145		222,206	970,351

1. THE CORPS OF ENGINEERS, SAN FRANCISCO DISTRICT IS PREPARING THE TECHNICAL PART OF THE SURFACE RUNOFF MANAGEMENT PLAN FOR THE LIVERMORE-AMADOR VALLEY AS PART OF THE CORPS OF ENGINEERS' URBAN STUDY PROGRAM.
2. CONTRACT NOT EXECUTED.
3. THE SURFACE RUNOFF MANAGEMENT PLAN FOR SAN FRANCISCO COUNTY IS NOT FUNDED THROUGH THE 208 PROGRAM BECAUSE THE COUNTY'S PLAN HAS ALREADY BEEN DEVELOPED.

2. Coordination and assistance in carrying out water quality monitoring programs

3. Information concerning a wide range of control measures for consideration in plan development

4. Procedures for assessing the economic, social and environmental effects of possible control measures

5. Regional land use, population and employment projections

6. Background information and advice on institutional-financial mechanisms for carrying out the county plans

7. Advice and assistance on the conduct of a public participation program in each county in support of plan development.

ABAG support and assistance to the counties will be given in various forms. These include a sequence of technical workshops, meetings with county staffs and consultants for developing the plans, furnishing pertinent written materials and documents to county staffs, identifying common problems, exchanging information on findings, and modifying work programs whenever needed. The way in which county agencies organize to carry out the work, including use of consultants, has been left to each county's discretion.

C. RELATIONSHIP OF SRMP STRUCTURE TO STRUCTURE OF OVERALL EMP PROGRAM

Figure 2 shows ABAG's organizational structure for preparation of the management plans. Each of the plans will be prepared by September, 1977. Then the plans will be integrated with each other to form an Environmental Management Plan with seven, regionally consistent elements. During this integration phase, from September, 1977 to March, 1978, the functional organization will change. It will then probably consist of a smaller group of key staff from ABAG and other agencies.

Figure 3 shows the overall organization for plan preparation. The Environmental Management Task Force (EMTF) is the body established by the ABAG Executive Board to manage the preparation of the EMP. The task force has 43 members. A majority of members are local elected officials. There are also representatives of regional agencies and special and public interest groups. The role of EMTF is (1) to prepare the work program and budget, (2) adopt procedures, assumptions, criteria, and standards, (3) approve the seven management plans, and (4) to ensure the concerns of citizens are reflected in the planning process. The EMTF has four committees:

- Work Program and Budget Committee
- Public Participation Committee
- Planning Procedures Committee

FIGURE 2

ENVIRONMENTAL MANAGEMENT PLAN ABAG FUNCTIONAL ORGANIZATION

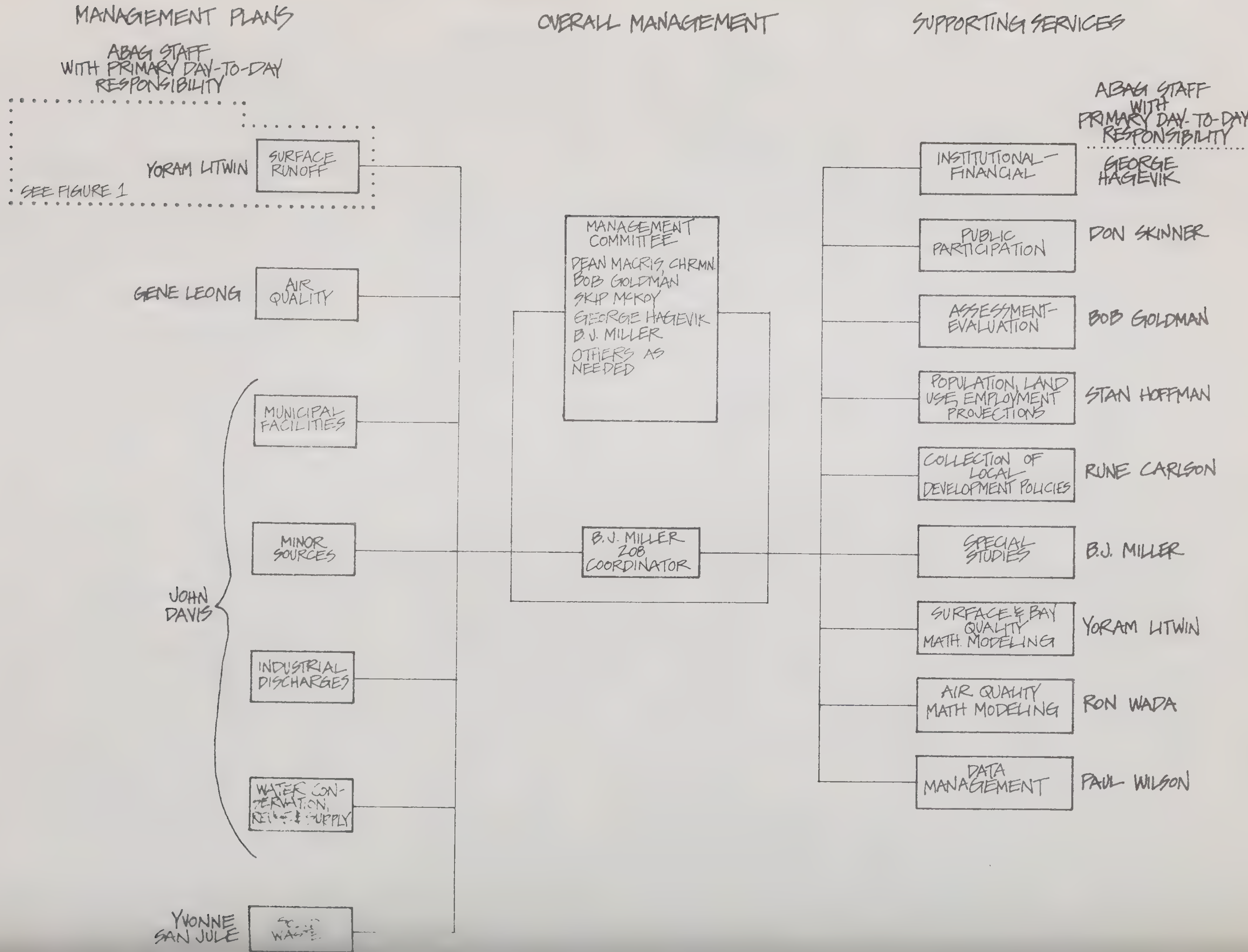
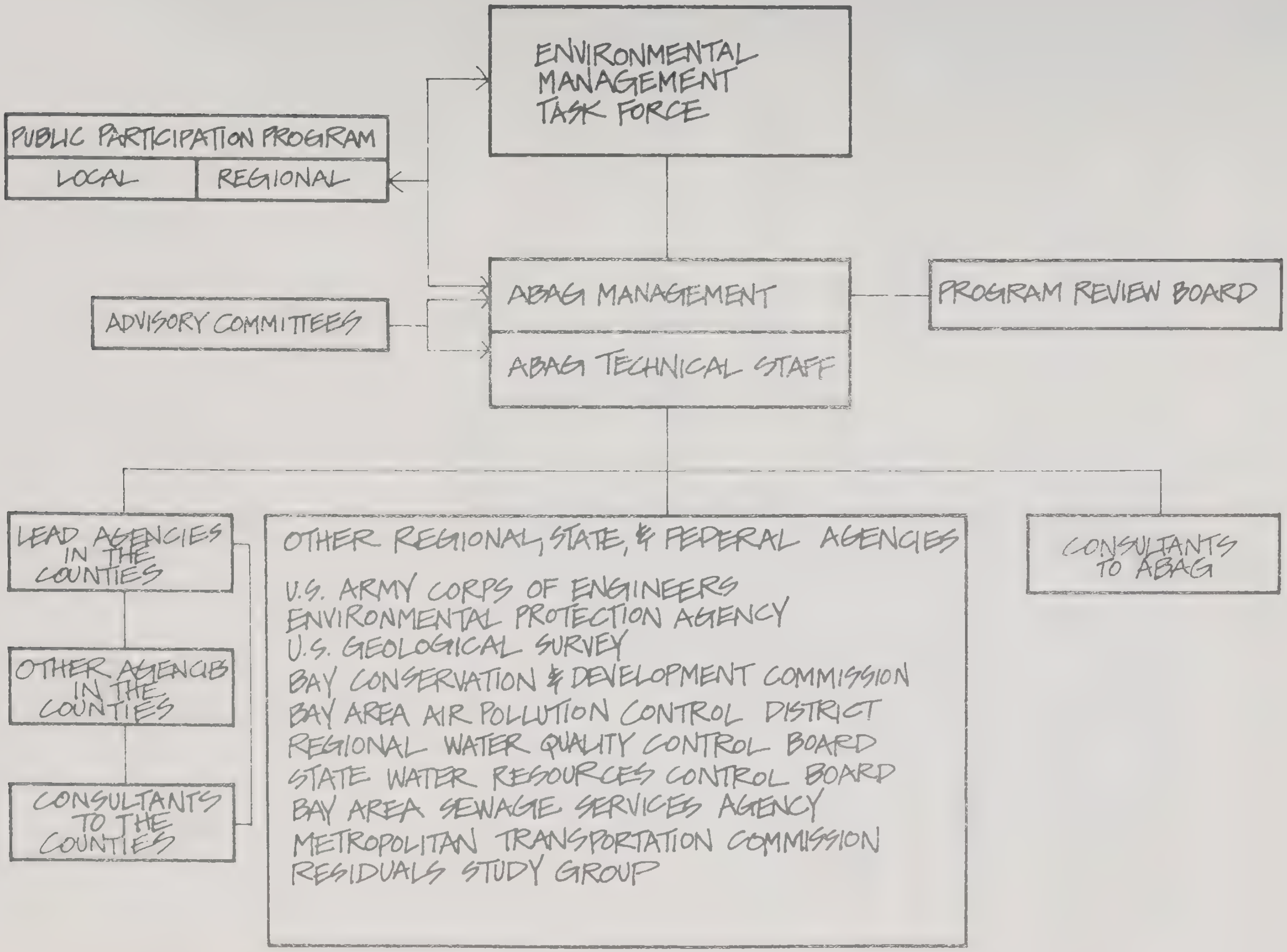


FIGURE 3

ORGANIZATION FOR PLAN PREPARATION



- Plan Implementation Committee

The purpose of this board is to provide advance notice of the positions of the member agencies on various issues. The agencies on the board are key agencies in the approval process. Therefore, the board provides early warning of problems to be encountered in getting the plan approved.

The work of ABAG's staff is assisted by nine advisory committees. The advisory committees are composed of local, regional, State and Federal Agencies, representatives of public and special interest groups, and individuals with pertinent special knowledge. The members are recommended by EMTF and ABAG staff. The nine committees are:

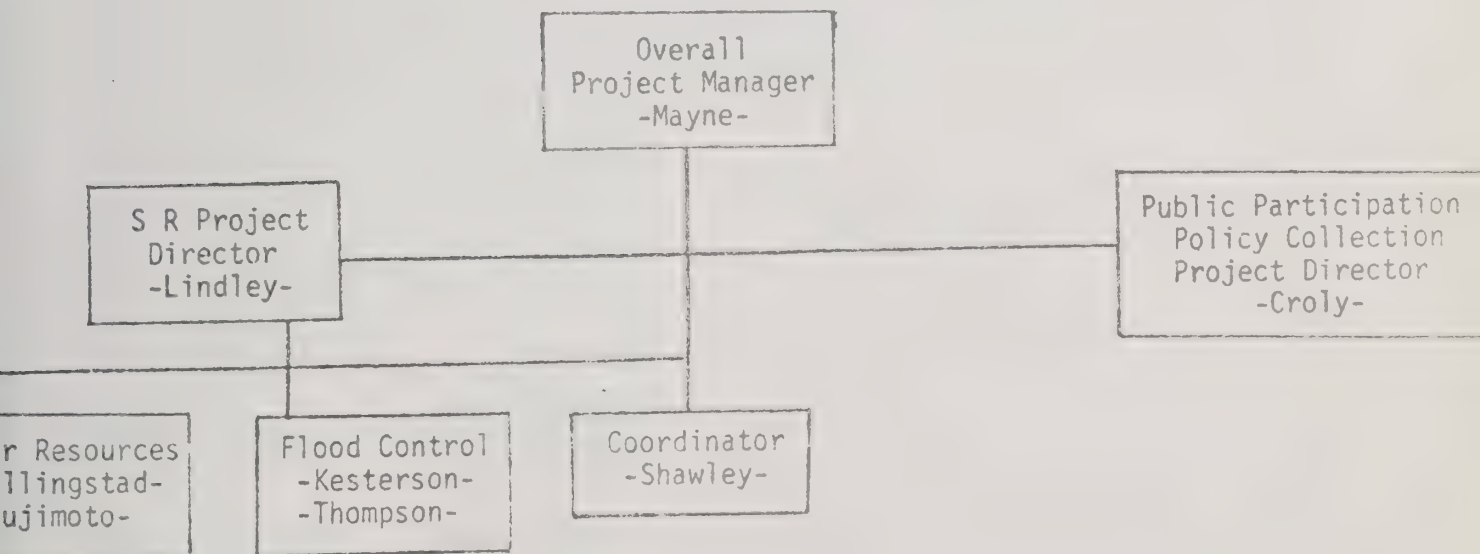
- Municipal/Industrial Discharges Management Plans Advisory Committee
- Air Quality Maintenance Plan Advisory Committee
- Solid Waste Management Plan Advisory Committee
- Water Conservation, Reuse, and Supply Advisory Committee
- Special Studies Advisory Committee
- Surface Runoff and Minor Sources Management Plans Committee
- Lead Agency Coordination Committee
- Assessment Advisory Committee
- Projections Technical Advisory Committee

D. STRUCTURE OF COUNTY PROGRAMS

1. Alameda County Surface Runoff Management Program Staff:

POSITION	NAME	TELEPHONE
Coordinator	Gary Shawley	881-6485
Overall Project Manager	Roland Mayne	874-7861
Surface Runoff Director	Jack Lindley	881-6485
Public Participation & Policy Collection Director	Betty Croly	881-6401
Water Resources Engineer	Jerry Killingstad	881-6401
Water Resources Technician	Kenji Fujimoto	881-6401
Flood Control Staff	Tom Thompson & Rich Baker	881-6401
Computer Assistant Engineer	Colin Kesterson	881-6401

ORGANIZATION CHART

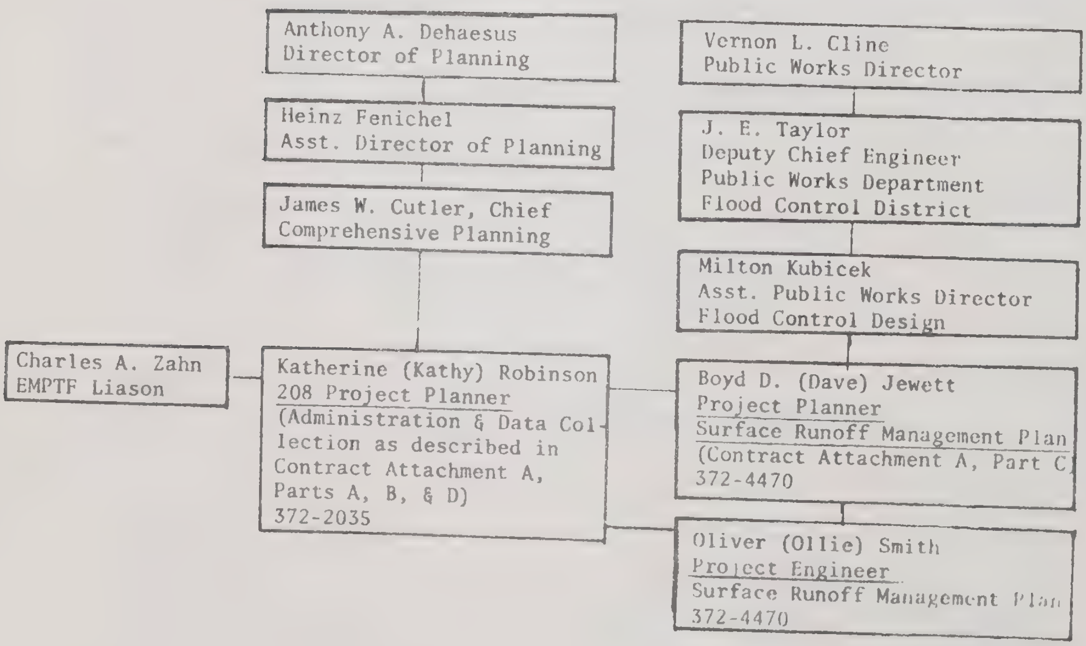


A note on protocol: All communication related to technical questions on the surface runoff portion should be directed to Gary Shawley. Questions concerning public participation and/or local policy collection should be directed to Betty Croly.

2. Contra Costa County Surface Runoff Management Program Staff:

POSITION	NAME	TELEPHONE
Overall Project Manager	Vernon L. Cline	(415) 372-4470
Overall Project Manager	J. E. Taylor	"
Surface Runoff Director	Milton Kubicek	"
Project Planner	Boyd D. (Dave) Jewett	"
Project Engineer	Oliver (Ollie) Smith	"
Hydrologist	Baolin Wu	"
Project Engineer	Lu Hurley	"

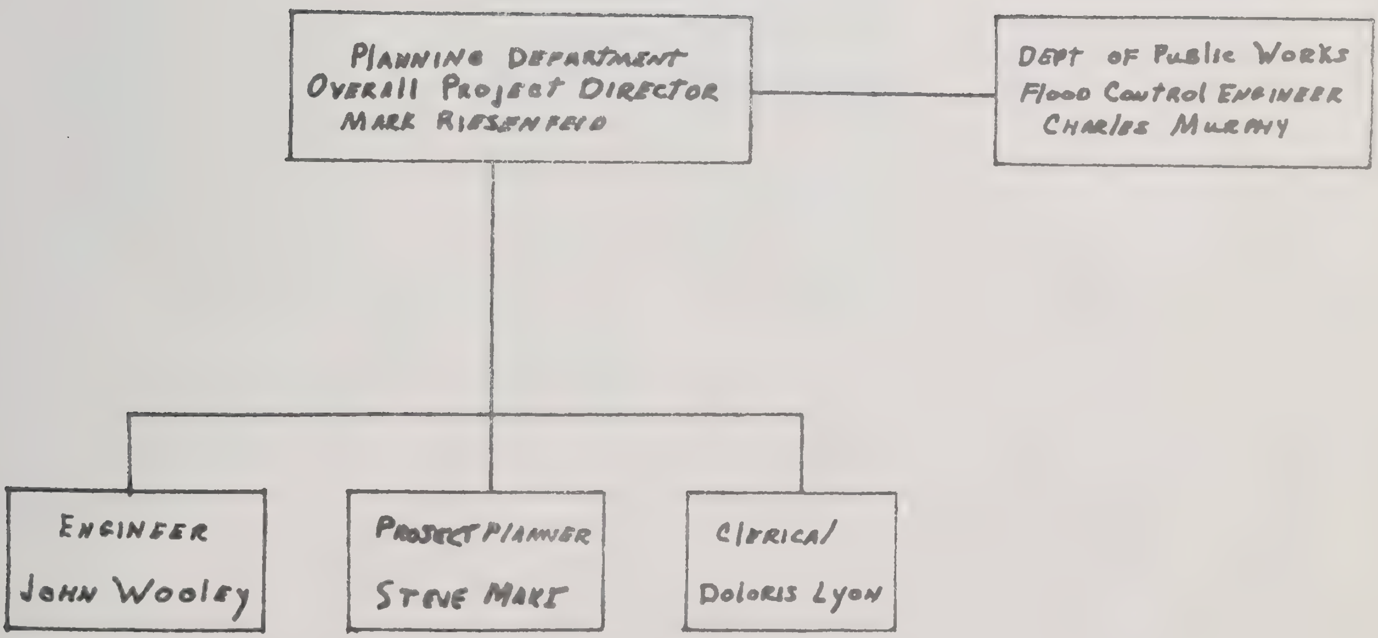
ORGANIZATION CHART



3. Marin County Surface Runoff Management Program Staff:

POSITION	NAME	TELEPHONE
Overall Project Director	Mark Riesenfeld	(415) 479-1100
Surface Runoff Manager	John Wooley	"
Flood Control Engineer	Charles Murphy	"
Project Planner	Steve Maki	"

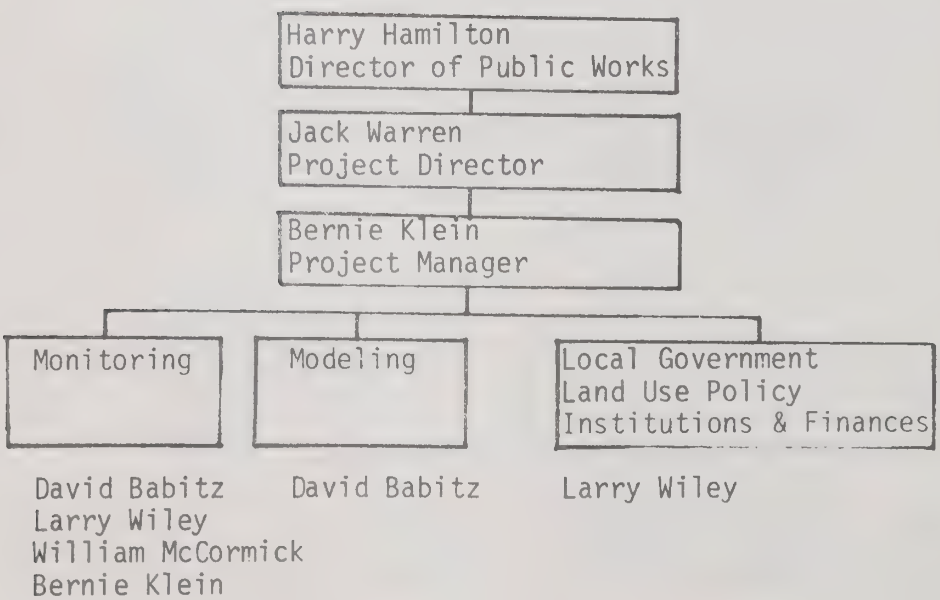
ORGANIZATION CHART



4. Napa County Surface Runcff Management Program Staff:

POSITION	NAME	TELEPHONE
Overall Project Director	Harry Hamilton	(707) 253-4351
Project Director	Jack Warren	"
Surface Runoff Manager	John Bernard Klein	"
Water Quality Engineer	Herb Knierm	"
Engineering Assistant	Larry Wiley	"
Water-Sewer Operator	William McCormick	"
Assistant Civil Engineer	David Babitz	"

ORGANIZATION CHART



5. San Mateo County Surface Runoff Management Program Staff:

POSITION	NAME	TELEPHONE
Coordinator	Neil R. Cullen	(415)364-5600

ORGANIZATION CHART

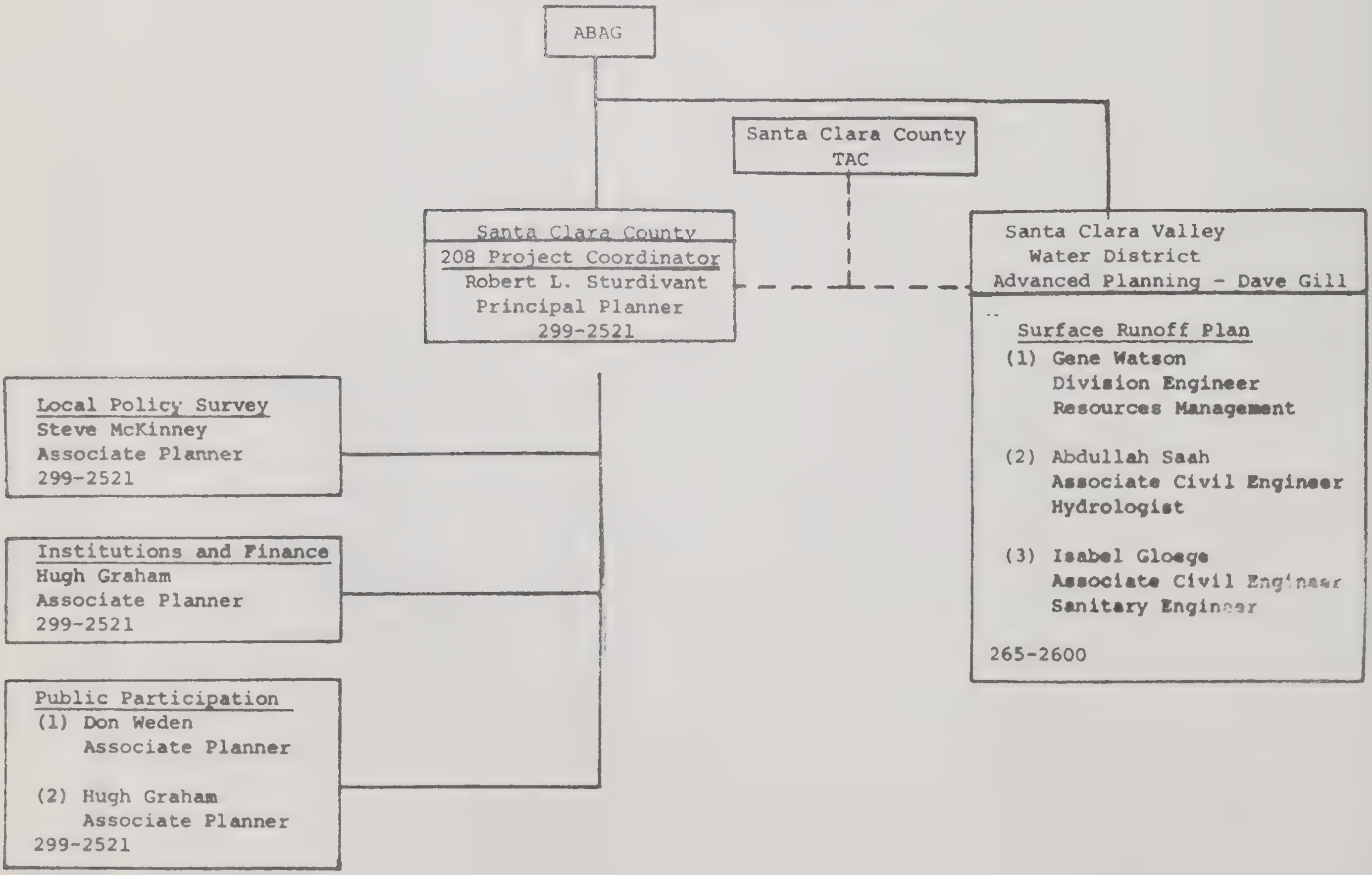
not determined at this time

6. Santa Clara County Surface Runoff Management Program Staff:

POSITION	NAME	TELEPHONE
Overall Program Director	Robert L. Sturdivant	(408) 299-2521
Director of Surface Runoff	Dave Gill	(408) 265-2600
Surface Runoff Manager	Gene Watson	"
Hydrologist	Abdullah Saah	"
Water Quality Engineer	Isabel Gloege	"

ORGANIZATION CHART

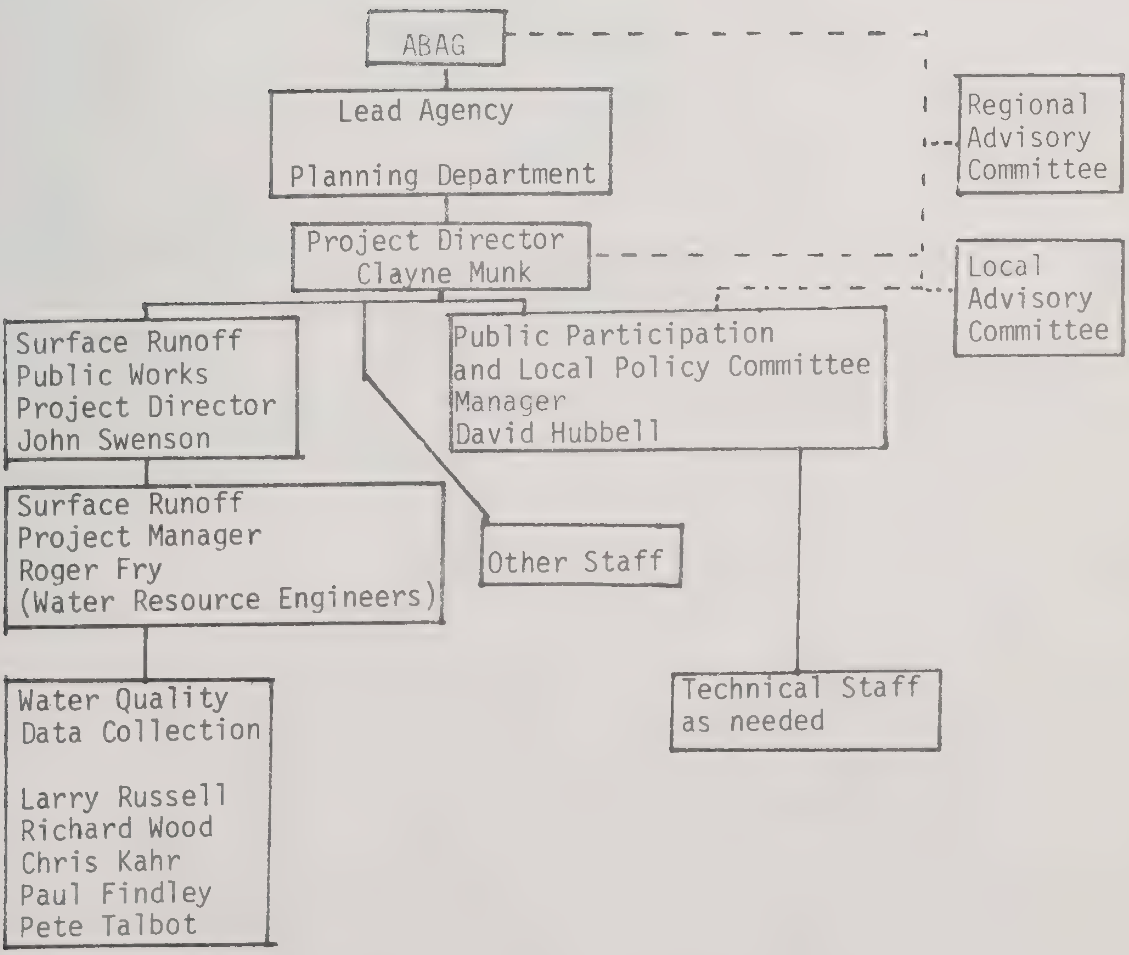
FUNCTIONAL ORGANIZATIONAL CHART
208 STUDIES - SANTA CLARA COUNTY



7. Solano County Surface Runoff Management Program Staff:

POSITION	NAME	TELEPHONE
Overall Project Director	Clayne Munk	(707) 429-6561
Surface Runoff Project Director	John Swenson	(707) 429-6266
Surface Runoff Manager	Roger Fry (WRE, Inc.)	(415) 933-4500
Water Quality Data Collection	Larry Russell (Montgomery Engrs.)	(415) 933-2250

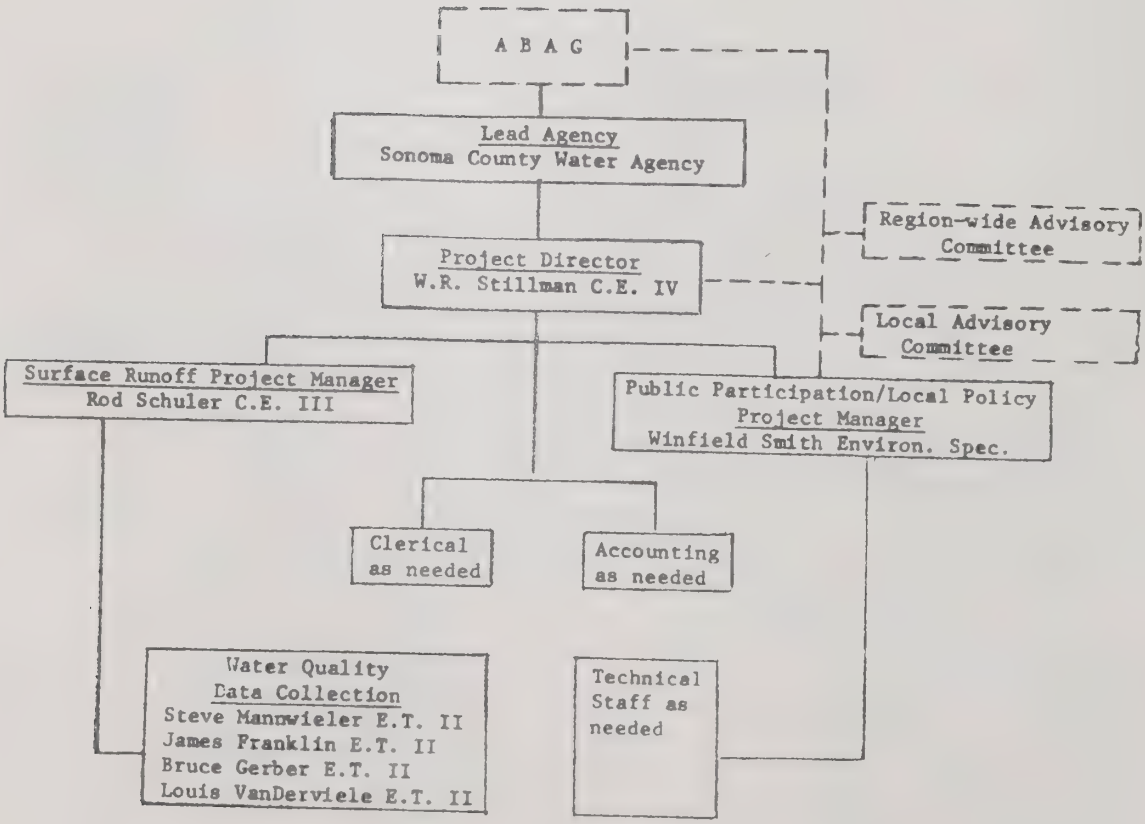
ORGANIZATION CHART



8. Sonoma County Surface Runoff Management Program Staff:

POSITION	NAME	TELEPHONE
Overall Project Director	Carl R. Jackson	(707) 527-2211
Project Director	W. R. Stillman	"
Surface Runoff Manager	Rod Schuler	"

ORGANIZATION CHART



E. STRUCTURE OF ABAG SURFACE RUNOFF MANAGEMENT PROGRAM

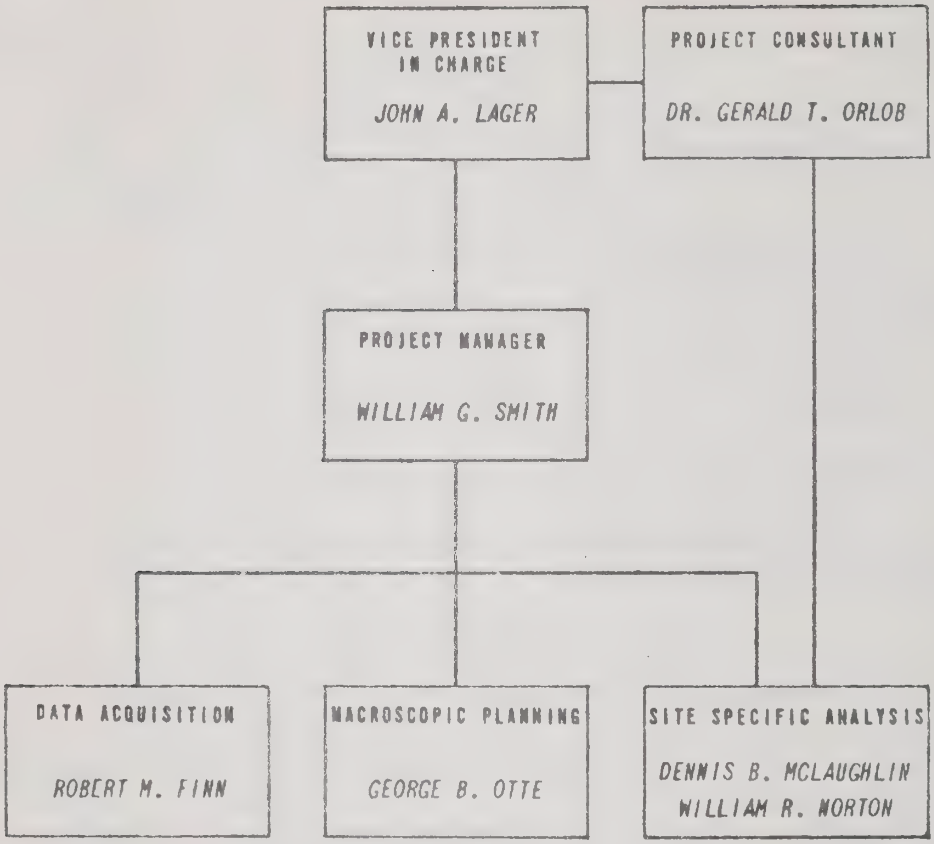
1. ABAG Staff

POSITION	NAME
Program Manager for Surface Runoff Management Plan	Yoram Litwin
Task Leader for Site Specific Analyses and Assistant Program Manager	Steve Goldman
Task Leader for Macroscopic Planning	Marcine Martin
Task Leader for Monitoring	Joseph Eilers
Task Leader for Coordination with ABAG Supporting Services	Robert Frommer

2. Surface Runoff Modeling Consultants (consultants to ABAG)

POSITION	NAME	TELEPHONE
Vice President in charge	John Lager	(415) 964-7100
Project Manager	William Smith	(415) 964-7100
Project Consultant	Gerald Orlob	(415) 284-9071
Macroscopic Planning	George Otte	(415) 964-7100
Data Acquisition	Robert Finn	(415) 964-7100
Site Specific Analysis	Dennis McLaughlin	(415) 284-9071
Site Specific Analysis	William Norton	(415) 284-9071

ORGANIZATION CHART:



F. SURFACE RUNOFF AND MINOR SOURCES MANAGEMENT PLAN COMMITTEE

This committee consists of two sub-groups: an advisory group and a coordination group. The advisory group consists of representatives of local, regional, state and federal agencies and representatives from various special and public interest groups. It is a non-voting body with a present membership of 25. The role of the advisory group is to (1) to review and advise on the overall direction and progress of the work, (2) review and comment on interim products and the final plan, and (3) represent the points of view of government agencies, public, and special interest groups.

Below is the membership roster for the advisory group:

ORGANIZATION OR GROUP PRESENTED	NAME	TELEPHONE
Local Agencies		
Resource Conservation Districts	Thomas Holmes	(415)687-1780

ORGANIZATION OR GROUP REPRESENTED	NAME	TELEPHONE
Regional Agencies		
San Francisco Bay Regional Water Quality Control Board	Bob Roche	(415)464-1255
San Francisco Bay Conservation and Development Commission	Tom Tobin	(415)557-3686
East Bay Municipal Utility District	Keith Carns	(415)835-3000
State Agencies		
State Water Resources Control Board	Merry Bernard	(916)322-4501
Coastal Commission	Jack Schoop	(415)557-1001
U.C. Agricultural Extension	Dr. Robert Hagen	(916)752-0457
Divison of Forestry	Ray Jackman	(408)372-4536
Federal Agencies		
U.S. Army Corps of Engineers	Wayne Olsen	(415)556-0985
Environmental Protection Agency	Harry Seraydarian	(415)556-7832
U.S. Geological Survey	Gary Pederson	(415)323-8111
Maritime Administration	John W. Hendricks	(415)556-6233
Special and Public Interest Groups		
Private industry	Ronald T. Calhoun	(415)349-2151
Bay Area Council and Peninsula Manufacturers Assoc.	W.W. Wilcox	(415)876-3144
Kaiser Cement & Gypsum Corp.	R.H. Berby	(415)271-2211

ORGANIZATION OR GROUP PRESENTED	NAME	TELEPHONE
Chevron Chemical	J.D. Turman	(415)235-9300
Stauffer Chemical	Thomas J. Meyers	(415)529-2910
Woodward-Clyde Consultants	Gail B. Boyd	(415)956-7070
McKay & Somps	Ted Fairfield	(408)732-8300
Kimura/Garfinkel	Masaru Kimura	(415)326-0941
U.A. Local #159	Dennis Gifford	(415)229-0774
EMTF	Helen Burke	(415)527-0176
EDF	Debbie Jackson	(415)548-5669
League of Women Voters	Gloria Duncan	(415)924-5669
Save San Francisco Bay Association	Steve McAdam	(415)849-3053

The coordination group of the the Surface Runoff and Minor Sources Management Plans Committee is a working unit of the managers of each county's surface runoff program. Its role is to assist in the coordination of work in and among the participating counties. This group presently consists of the following 23 members:

AGENCY or DEPARTMENT	NAME	TELEPHONE
Alameda County Flood Control and Water Conservation District	Jack Lindley Gary Shawley	(415)881-6470 "
Alameda County Administrator's Office	Roland Mayne	(415)874-7861
Contra Costa County Planning Department	Anthony Dehaesus Charles Zahn	(415)372-2035 "
Contra Costa County Public Works Department	Vernon Cline Oliver Smith	(415)327-2035 "
Marin County Planning Department	Mark Riesenfeld	(415)479-1100
Marin County Public Works Department	Charles Murphy John Wooley	(415)479-1100 "

AGENCY or DEPARTMENT	NAME	TELEPHONE
Napa County Public Works Department	Jack Warren Bernie Klein	(707)253-4351 "
San Mateo County Planning Department	Bill Powers	(415)364-5600
San Mateo County Public Works Department	Vic Sanders Neil Cullen	(415)364-5600 "
Santa Clara County Planning Department	Robert Sturdivant	(408)299-25 1
Santa Clara Valley Water District	Dave Gill	(408)265-2600
Solano County Planning Department	Clayne Munk	(707)429-6561
Solano County Public Works Department	John Swenson	(707)429-6266
Sonoma County Water Agency	Bill Stillman Rod Schuler	(707)527-2211 "
U.S. Army Corps of Engineers, San Francisco District (assisting in Alameda County)	Wayne Olsen	(415)556-0985

APPENDIX

Biographical Sketches of Surface Runoff Management Program Staffs and Committee Members

COUNTY SURFACE RUNOFF MANAGEMENT PROGRAM STAFFS

Alameda County

Gary W. Shawley - Master's degree, major Environmental Planning (Fla. State Univ.). Bachelor's degree in political science. Previous experience in public opinion and market surveys, public relations and political campaign management. Minimal background in applying computer model results. Current position - Flood Control District 208 Coordinator.

Colin Kesterson - Bachelor's degree, major Civil Engineering (Berkeley). Previous experience of six years with Caltrans. Served as a troubleshooter in the use of batch and time sharing computer programs. Some experience with "Basic" language.

Bruce Knopf - Bachelor's degree, major Civil Engineering (Berkeley). Previous experience of three years with Flood Control District. Moderate backgound in hydraulic design, hydrological analysis, flood routing and detention basin design. Minimal background with "Fortran" language.

Ed Cummings - Engineer; In charge of technicians performing the sampling. Minimal background in water quality sampling.

Kenji Fugimoto - Technician; Responsible for collecting most of the samples in the District's current surface water program. Approximately three years experience in collection of groundwater samples for chemical analysis. Familiar with filtering procedures, treating samples with acids, and use of field instruments such as pH meters, conductivity meters, and chloride test kits.

Jeff Morrison - Technician; Approximately one year experience in collection of groundwater samples. Experienced in flow measurement of surface water. Some previous experience with collecting surface water samples for chemical analysis.

Contra Costa County

Boyd Jewett - Senior Civil Engineer, BS-CE; Registered Civil Engineering-Calif; Assist head - C.C.C. Flood Control Planning & Design Division.

Oliver Smith - Environmental Control Engineer, BS-CE; Registered Civil Engineering-Calif; Project Engineer for ABAG 208 Surface Runoff Management Study for C.C.C.

Baolin Wu - Hydrologist, Ph.D; In charge of all hydrologic activities, special interests in frequency analysis and hydrologic modeling.

Lou Hurley - Assistant Civil Engineer; Installation and maintenance of stream flow and rainfall gages, data collection, reduction and compilation.

Marin County

John Wooley - A graduate of San Jose State - 1971, Bachelor Science in Civil Engineering. Has been with Marin County on and off since 1972- in Land Development and Traffic Engineering and in September, 1976, began work on the Surface Runoff Management Plan.

Mark Riesenfeld - Bachelor's degree in Political Science, UCLA; Master's degree in Planning, USC. He has had 5 years of experience in dealing with land use problems, development programs and growth-management systems.

Napa County

Jack Warren, Senior Engineer, RCE #16057. Graduate of Chico State College 1960. Fifteen years experience in City and County Public Works, 10 with Napa County.

John Bernard Klein, Associate Engineer, RCE #21583. Twenty years experience in City and County Public Works. Mr. Klein is the person most responsible and involved in the 208 study.

Herb Knierm, Senior Engineer, RCE #19173, graduate BSCE Cal-Poly. Herb has been involved in water quality work for the last seven years.

Larry Wiley, Civil Engineering Assistant. Educated in Civil Engineering and employed with Napa County for the past 22 years. Primary background in construction inspection and contract administration.

William McCormick, Water-Sewer Operator. Employed last two years with Napa County, experience in water quality sampling and analysis.

David Babitz, Assistant Civil Engineer, Registered Civil Engineer, graduate of U.C. Davis. Employed by East Bay Municipal Utility District before coming to Napa County in 1973.

San Mateo County

Information not available at this time.

Santa Clara County

Gene Watson, Registered Civil Engineer with 18 years of experience in planning design and construction of flood control and water supply projects.

Abdullah Saah, Registered Civil Engineer with 14 years of experience in hydrology and the design and construction of hydraulic structures.

Isabel Gloege, M.S., Ph.D (course work) in sanitary, industrial, and chemical engineering with 7 years' experience in planning and design of water supply and wastewater treatment facilities.

Solano County

Clayne Munk, Planning Director; 20 years planning experience.

David Hubbell, Chief, Advance Planning, Land Use Planner; 6 years experience.

John Swenson, Flood Control Engineer, Civil Engineer, California license, 15 years experience.

Sonoma County

Bill Stillman and Rod Schuler, both are registered civil engineers in the State of California with strong backgrounds in design and construction of hydraulic facilities, including a knowledge of computer programming.

Steve Mannwieler and James Franklin, both are engineering technicians with broad backgrounds in construction inspection, soils testing, surveying, field investigations, stream gaging and drafting.

ABAG SURFACE RUNOFF MANAGEMENT PROGRAM STAFF

Yoram J. Litwin, Sr. Environmental Engineer, is Program Manager of the ABAG EMP Surface Runoff Management Plan. He received his Ph.D. in Civil and Environmental Engineering from the University of Wisconsin in Madison in 1974. He has nine years of professional experience in Water Resources and Environmental Systems Modeling and Analysis.

Steven J. Goldman, Regional Planner, received his B.S. in Conservation of Natural Resources at U.C. Berkeley and his Master of Regional Planning from the University of Pennsylvania in 1974. He has participated in comprehensive regional planning studies in New Jersey and Pennsylvania. Since joining ABAG he has served as contributing author to the "Integrated Land Use/Air Quality/Water Quality Control Study for Sonoma County, California" and is now serving as Assistant Manager of the SRMP and Task Leader for Site Specific Analysis.

Marcine Martin, Regional Planner, received her M.A. in Geography from U.C.L.A. (1975). At U.C.L.A. she was employed as a Research Associate specializing in computer programming and statistical analysis. At ABAG she has participated in the "Integrated Land Use/Air Quality/Water Quality Control Study. In addition to assisting the counties as task leader for Macroscopic Planning in the Surface Runoff Management Program, she is also participating in the Minor Sources Management Program.

Joseph M. Eilers received his M.S. in Water Resources Management from the University of Wisconsin-Madison in 1976. His research dealt with monitoring and control of non-point source pollution in Milwaukee and rural areas of Wisconsin. He will be assisting the counties in monitoring surface runoff.

Robert Frommer received his B.S. in Physics from M.I.T. in 1966. He earned his M.S. in Physics in 1967 at the University of Wisconsin in Madison and remained there as a research assistant for four years, spending part of that time at the Lawrence Berkeley Laboratory. In 1972, he joined the EPA, Region IX, San Francisco office, as a physicist specializing in air and water quality mathematical modeling. He then worked for the air quality branch of the Ministry of Commerce in Israel in 1974, and joined ABAG in late 1974 where he specializes in the modeling of the air and water quality aspects of regional development.

John F. Shaffer, Intern at ABAG with Air/Water Quality Division; B.S.-Conservation of National Resources 1975, emphasis on Environmental Law Planning and Administration, U.C. Berkeley. A.S.-Degree Merritt College; 3 years work experience with Merritt College's student/college Office of Environmental Projects, and Environmental Studies.

Fredrick M. Wolin, Intern at ABAG with Air/Water Quality Division; Associate in Science Degree in Environmental Studies, Merritt College, Oakland. Candidate for B.S. Degree in Conservation of Natural Resources, emphasis on Environmental Planning & Resource use, University of California, Berkeley.

ABAG SURFACE RUNOFF MODELING CONSULTANTS

John A. Lager, Vice President and Chief Engineer of the Western Regional Office of Metcalf & Eddy, Inc., is vice president in charge of the Surface Runoff modeling contract. He has had 15 years of professional engineering experience since receiving his MS in Sanitary Engineering from Harvard University, including extensive developmental and application work in stormwater runoff modeling and analysis, and treatment plant design. Earlier this year he received the 1976 ASCE State-of-the-Art of Civil Engineering Award, and he is a registered engineer in five states.

Gerald T. Orlob, Project Consultant, is Professor of Civil Engineering, University of California, Davis, and President, Resource Management Associates. Since the early 1960's he has been active professionally in research and development of mathematical models and in the application in environmental management of these and other tools of systems analysis. He has served as consultant to state, national and international organizations in matters concerned with water resources and water quality management.

William G. (Mike) Smith, of Metcalf & Eddy, Inc., is the Project Manager of the Surface Runoff modeling contract. He received his MS in Sanitary Engineering from San Jose State College in 1967 and has planned, managed and designed projects including substantial work in the development of the EPA Stormwater Management Model (SWMM) and applications of this model, reviews of stormwater treatment and control techniques, and solid waste management.

George B. Otte, Project Engineer, Metcalf & Eddy, Inc., received his MS in Environmental Engineering from UC Davis in 1974. He specializes in macroscopic stormwater runoff analysis and has also worked on a number of design studies for municipal and industrial wastewater treatment facilities.

William R. Norton, Associate, Resource Management Associates, has been working in the field of hydraulic and sanitary engineering since receiving his MS from UC Berkeley in 1963. He was project manager for computer applications for the large rainfall/runoff study of Seattle, which made extensive use of the SWMM model. He also has experience in water quality data collection programs.

Dennis McLaughlin, Associate, Resource Management Associates, received his MS in Systems Engineering from Princeton University in 1967. For the past four years he has managed or participated in numerous projects in environmental engineering. These have included development of automatic calibration algorithms, hydrodynamic simulation of stratified estuaries and dynamic flood routing modeling.

Robert M. Finn, Project Engineer, Metcalf & Eddy, Inc., received his MS in Sanitary Engineering from Oregon State University in 1974. He has worked in the fields of stormwater management, including EPA 208 programs, water pollution control, including municipal and industrial treatment and discharge facilities and solid waste management.

SURFACE RUNOFF AND MINOR POINT SOURCES MANAGEMENT PLAN COMMITTEE

Advisory Group

R.H. Berby, Manager of Environmental Control and Energy for Kaiser Cement and Gypsum Corporation, received his MBA from the University of Santa Clara. He is currently Chairman of Environmental Quality for the California Manufacturers Association.

Merry Bernard, is employed by the State Water Resources Contol Board. She received her B.A. in economics from California State University, Sacramento.

Gail Boyd, Senior Project Engineer for Woodward-Clyde Consultants obtained his MS degree from San Jose State University. He has authored studies on street surface contaminants and urban runoff.

Helen Burke, serves on the Board of Directors for the East Bay Municipal Utilities District. She is also serving on and representing the Environmental Management Task Force.

Ronald T. Calhoun, Vice President of Wilsey and Ham, received his B.S. in civil engineering from UCLA. As an engineer for Wilsey and Ham, he has been responsible for many engineering and planning programs.

Keith E. Carns, is Supervisor of the Water Quality Section of the East Bay Municipal Utility District. He possess a M.S. degree in Sanitary Engineering from U.C. Berkeley.

Gloria Duncan, serves as the League of Women Voters representative on the Water Committee for the State of California. She is also Chairman of Environmental Quality for the League of Women Voters and is a member of the Marin Planning Commission.

Ted Fairfield, President of MacKay and Somps' Environmental Center, is a registered civil engineer in four states. He has been employed by Mackay and Somps for 17 years and is President-Elect of the California Council of Civil Engineers and Surveys.

Dennis Gifford, represents The Plumbers and Steamfitters Union, Local 159. He is also President of the Contra Costa Building and Construction Council.

Dr. Robert M. Hagan, U.C. Cooperative Extension, received his Ph.D from the University of California at Davis. As a professor of water science he has been involved in water research and teaching since 1946.

John Hendricks, is presently working for the Maritime Administration. He received his M.A. degree in Geography from San Francisco State University. Past efforts have included work for the California Coastal Zone Commission, specializing in near-shore processes.

Thomas Holmes, Contra Costa Resource Conservation District, received his B.S. degree from Cal Poly at San Luis Obispo in agronomy. He has also done graduate work at the University of Oklahoma in economics of resource conservation.

Ray Jackman, represents the Central Coast Region of the California Division of Forestry. He received his Master's degree in forestry from Oregon State University, and is currently project supervisor for a watershed experimental project in Jakcson State Forest.

Debbie Jackson, Environmental Defense Fund, received her B.S. degree in environmental planning from the University of California at Davis. In addition to her work for EDF, she has served for two years with the Planning and Conservation League.

Masaru Kimura, Kimura/Garfinkel, received his B.S. in Landscape Architecture from U.C. Berkeley. His professional interests are: environmental planning, soils and erosion control.

Steve McAdam, serves as Field Coordinator for Save San Francisco Bay Association. He received his B.A. in history from U.C. Santa Barbara with a minor in environmental studies.

Thomas J. Meyers, Research Chemist, received his Ph.D in chemistry from U.C. Berkeley. As a chemist for Stauffer Chemical Company, his work has involved research associated with wastewater analysis.

Wayne Olsen, U.S. Army Corps of Engineers, received his M.S. in environmental engineering from San Jose State University. In addition to his two years with the Army Corps, he served as an environmental engineer for the U.S. Navy in point and non-point source pollution control.

Gary L. Pederson, Supervising Hydrologist with the Water Resources Division of USGS, Menlo Park Subdistrict received his Ph.D. in Sanitary Engineering from the University of Washington in 1972. He joined the USGS in 1974 and is presently project chief for (1) design of a water quality survey network for Santa Clara County, and (2) water quality studies of the Upper Napa River.

Bob Roche, Represents the California State Regional Water Quality Control Board in the capacity of sanitary engineer.

L. Wade Rose, serves in the Governor's office of Appropriate Technology. He received his B.A. in psychology from California State University, Sonoma.

Jack Schoop, is chief planner for the California Coastal Commission in San Francisco. He obtained his masters degree from Massachussetts Institute of Technology in planning.

Tom Tobin, Senior Engineer, is employed by the Bay Conservation and Development Commission. He posses a masters degree in civil engineering from San Jose State University with emphasis on soil mechanics and geology.

J.D. Turman has been a research engineer for Chevron Chemical Co. for the past 10 years. His B.S. degree in chemical engineering was obtained from Stanford University.

W.W. Wilcox representsthe Bay Area Council and Peninsula Manufacturers Association. He has a B.S. in aeronautical engineering and business administration from the University of Minnesota. His current position is with the Environmental Affairs Maintenance Operations Center at the San Francisco International Airport.

COORDINATION GROUP:

See County Surface Runoff Management Program Staffs

SURFACE RUNOFF MANAGEMENT PLAN

VISIBILITY OF WATER QUALITY PROBLEMS
A SURVEY OF WARNING SIGNS IN THE BAY AREA

ISSUE PAPER NO. 2

NOVEMBER 9, 1977

A. PURPOSE OF THIS ISSUE PAPER

The purpose of this issue paper is to document the visibility of water quality problems relating to public health as evidenced by public warning notices. It must be understood that this survey does not serve the purpose of actually identifying water quality problems. It is merely an indicator of how such problems are made visible to the public.

B. CONCLUSION

Although the water quality problems related to surface runoff are diverse in nature and are widespread throughout the waters of the region, the public visibility of these problems is essentially limited to a small number of warning signs. The majority of these signs focus on bacterial contamination, since this problem poses the most imminent health hazard. The problems caused by sediment, heavy metals, oil and grease, pesticides and other toxic substances are much more subtle and therefore go largely unnoticed. Only a very few signs deal with sediment and heavy metal pollution. None deal with oil, grease, pesticides, litter and debris. Aesthetic pollution caused by the presence of the above contaminants occurs throughout the region's waters. However, the visibility of these problems is limited and therefore the public perceives it as a low priority item.

The water pollution problems indicated by the warning signs posted across the region are related in varying degrees to surface runoff. It is interesting to note that the frequency of posting of these signs during the past two years has been reduced due to the recent drought. As rainfall increases, the number of warning signs posted will probably also increase.

The contacts with the surveyed organizations revealed the following perception of Bay water quality as it relates to shellfish harvesting:

- Shellfish harvested from Bay water cannot be consumed with total confidence that they are free from harmful substances.

- The State Department of Public Health will not state that it is safe to consume shellfish harvested from San Francisco Bay.

- The State Department of Fish and Game will not state that it is safe to consume shellfish from San Francisco Bay.

- Health Department officials have stated that there is a possible health hazard from viral contamination of shellfish.

- It has been stated that the only way to be reasonably sure that the shellfish harvested from the Bay are safe to eat is to subject them to either the process of depuration or use a relaying operation before consumption. Depuration is a process of flushing shellfish with water that is known to be pure. Relaying is the harvesting and transferring of the shellfish to unpolluted shellfish beds for a period of about thirty days before reharvesting for consumption.

- Some of the known shellfish beds are posted as to the dangers of consuming shellfish harvested from the Bay.

- Sedimentation is a problem in some lakes. Lake Temescal is posted as to the physical danger of people being trapped in soft mud.

C. PUBLIC PERCEPTION OF WATER QUALITY

A major difficulty in developing the Surface Runoff Management Plan is the public's lack of information about water quality problems and their toleration of the problems which are visible. Over the past two decades, a significant improvement in the quality of Bay water has taken place. The problems today are no longer those of widespread odor or imminent health hazards, as shown by the paucity of warning signs. They are often subtle and their effects may only be shown after accumulation over a long period of time. Included in this category are carcinogenic materials, heavy metals, and other toxic compounds. The effects of such substances are not entirely understood by scientists and are not visible to the public.

D. SOURCES OF INFORMATION

A large number of organizations were contacted during this survey. These sources are presented in Table 1. The agencies contacted were very

TABLE I. A SURVEY OF PUBLIC HEALTH WARNING SIGNS

Organization	Exhibit #	Contact	Comments
Alameda County Department of Health	9, 16, 17	Storm Goranson (415) 874-6434	Alameda County Health Department recommended to post warning signs around Lake Merritt due to bacterial contamination.
Contra Costa County Department of Environmental Health	18		Warning signs are posted only if directed by State Health Dept., or other agency with jurisdiction.
Marin County Public Health Dept.	10, 14, 19, 20	Mr. Stewart (415) 479-1100	The most significant water quality problems are around Richardson Bay which has had some high bacteria counts in the past. This is probably due to stormwater runoff and improper sewage disposal facilities in the area.
Napa County Health Dept.	2, 3, 6	Trent Cave (707) 429-6241	No signs posted along the Bay shoreline. Signs used for fresh water only.
Santa Clara County Public Health.	4, 15	Keith Kraft	Mercury contamination of fish in Calero Reservoir is a continous problem. Bay shoreline is not posted because there is no public access to the Santa Clara shoreline.
San Francisco Department of Public Health	5, 8, 22	Mr. Lee (415) 558-4731	Pollution signs around sewage outfalls to the Bay have not been posted during the past two years due to a lack of surface runoff (drought year). This problem will be reduced when the new storm sewer and treatment plant project is completed.
Berkeley Department of Public Health			

Organization	Exhibit #	Contact	Comments
San Mateo County Public Health Department	13, 21	Mr. Rex Goff (415) 364-5600	Two shellfish beds are posted for contamination in San Mateo County. However, in the recent years there has been a major improvement of water quality along the San Mateo Shoreline. It is attributed to the improved sewage treatment facilities. An investigation as to the possibility of a commercial shellfish harvesting and relaying operation being based on the San Mateo County shellfish beds is being done at present.
Solano County Dept. of Public Health	1	Mr. Carson (707) 429-6241	
Sonoma County Public Health Department		Don Smith	Bay Shoreline not posted due to inaccessability.
Golden Gate National Recreation Area	7, 11	Mr. Nadeau Mr. Trebaess	The State Dept. of Public Health posts signs warning of water quality.
U. S. Public Health Service			Concerned mostly with the Bolinas Lagoon bacteria problem. The U.S. Public Health Service does not get involved with Bay Area water quality problems unless contacted by the state or the area affected is under federal jurisdiction.
Pt. Reyes National Seashore		Mr. Jack Williams (707) 663-1092	Heavy recreational use has caused some of the surface water to be posted as polluted and non-potable.
State Dept. of Fish and Game		John Emig (707) 944-2443	

State Dept. of Public Health		Mr. Clifford Sharp	The State Department of Public Health does not endorse the consumption of shellfish harvested in San Francisco Bay because of high bacteria counts and the lack of sanitary surveys for shellfish harvesting areas. Viruses are another potential danger to consumers of San Francisco Bay shellfish. Surface Runoff is a major contributor of bacteria to the Bay.
Resource Conservation		Mr. Bill Bruner (415) 687-1780	Sediments are a pollution problem and should be dealt with by preventive measures.
East Bay Regional Park District	12	Steve Griffen	Heavy recreational use of park facilities if not regulated can cause pollution of surface water.
East Bay Municipal Utilities District		Pete Weeks	Regulations for recreational use of EBMUD lands are strictly enforced. The major concern is that water quality in the EBMUD reservoirs is unimparied by recreational use of watershed lands.

cooperative in providing the requested materials. Agencies contacted included: all county and city health departments, State Department of Public Health, Department of Fish and Game, East Bay Regional Parks, and two water supply districts, GGNRA,[1] Pt. Reyes National Seashore.

E. SIGN CATEGORIES

The water quality problems as seen through public warning notices are almost all concerned with immediate health hazards. They fall into one of four categories.

- *Pollution of Recreational Waters:* all counties in the region have posted warning signs at recreational water bodies prohibiting water contact (Exhibits 1 thru 11). The cause of the posting is high bacterial counts in the water. The incidence of posting has decreased during the drought, partially because of a reduction in surface runoff contamination.

- *Shellfish Contamination:* the waters of the San Francisco Bay are presently not open for commercial shellfish harvesting because of suspected bacterial contamination. The quality of the Bay, as measured by bacteria, has been improving in recent years because of the improvement in sewage treatment. During the dry season, some Bay waters are believed to be acceptable for harvesting, however, it is known that Bay bacteria levels increase significantly in the winter months. Although commercial shellfish harvesting is prohibited in the Bay, the status of recreational shellfish harvesting may be changed with the additional controls on surface runoff. Currently the State Department of Health and the Department of Fish and Game do not encourage individuals to gather Bay shellfish. Only Marin and San Mateo County health departments post signs warning of possible shellfish contaminated by bacteria (Exhibits 13 and 14). However, most counties[2] annually post their shores with a large number of mussel quarantine signs from May through October (Exhibits 16 thru 22). The main reason for posting these signs is to warn the public of possible paralytic shellfish poisoning. The poisoning results from shellfish accumulation of naturally occuring organisms which may reach high concentrations during the quarantine period. These signs do however, serve as a warning to the public of potential hazards from consuming shellfish contaminated by a variety of sources.

- *Contamination of Fish by Mercury:* Calero Reservoir in Santa Clara County is posted by the County health department, warning of high concentrations of mercury in the fish (Exhibit 15). The mercury is leached from processed ores left behind from abandoned mercury operations.

[1]Golden Gate National Recreation Area

[2]Sonoma and Santa Clara counties do not post mussel quarantine signs because the public lacks access to the shorelines.

- *Sediment Pollution:* only one lake in the region has sediment problems to such a degree that it is considered a public health hazard. Lake Temescal received large quantities of sediment during highway construction. This sediment accumulated at the inlet, prompting officials with East Bay Regional Park District to post an appropriate warning sign (Exhibit 12) because of the danger of people becoming trapped in soft mud.

APPENDIX

Exhibit	Content
1.	Water Unsafe for Water Contact Sports
2.	Warning Unsafe Water
3.	Warning Unsafe Water (in Spanish)
4.	Stream Polluted
5.	Warning Water Polluted
6.	Closure Sign
7.	Warning Contaminated Water
8.	Sewage Discharge Warning
9.	Polluted Water Warning
10.	Water Polluted Sign
11.	Contaminated Water Sign
12.	Sediment Warning Sign
13.	Shellfish Hazard Sign
14.	Warning, Water Polluted for Shellfishing
15.	Mercury Content of Fish Warning Sign
16.	Mussel Quarantine Sign, Alameda County
17.	Mussel Quarantine Sign, (in Chinese)
18.	Mussel Quarantine Sign, Contra Costa County
19.	Mussel Quarantine Sign, Marin County
20.	Mussel Quanantine Sign, Marin County (in Spanish)
21.	Mussel Quarantine and Clam Caution Sign, San Mateo Cou
22.	Mussel Quarantine Sign with Spanish and Filipino Translations, San Francisco

THIS WATER IS

UNSAFE

FOR

Water Contact Sports

POSTED BY

SOLANO COUNTY DEPARTMENT OF PUBLIC HEALTH

CALIFORNIA HEALTH AND SAFETY CODE SECTIONS 7958, 7960

DO NOT DESTROY THIS SIGN

Exhibit 1

PUBLIC NOTICE

WARNING!

UNSAFE WATER

Napa County Health Department

DO NOT REMOVE THIS NOTICE

Exhibit 2

NOTICIA AL PUBLICO

¡PELIGRO!

EL AGUA ESTA CONTAMINADA

EL DEPARTUMENTO DE NAPA COUNTY HEALTH

ESTA PROHIBIDO POR LA LEY

QUITAR ESTA NOTICIA

Exhibit 3

KEEP OUT
STREAM
POLLUTED

SANTA CLARA COUNTY
HEALTH DEPARTMENT

SANTA CLARA COUNTY HEALTH DEPT.

WARNING

THIS WATER IS

POLLUTED

DO NOT USE

S. F. DEPT. PUBLIC HEALTH

CALMAR PRINTING CO. 375 FREMONT STREET

Exhibit 5

BY ORDER OF

NAPA COUNTY HEALTH DEPT

DIVISION OF

ENVIRONMENTAL HEALTH

CLOSED

1123 FIRST STREET, NAPA PH. 255-5966

DATE ______________ DIRECTOR ______________________

Exhibit 6

WARNING

CONTAMINATED WATER

Exceeds U.S. Public Health Standards for Public Use

DO NOT USE

Exhibit 7

WARNING

SEWAGE DISCHARGE

DO NOT USE
BEACH OR WATER

DEPT. PUBLIC HEALTH

Exhibit 8

WARNING

POLLUTED WATER

Swimming, Water Skiing Or Other Water Contact Sports In This Area Are Dangerous to Health

[redacted]

Alameda Co. Health Officer

Exhibit 9

WATER POLLUTED

DANGEROUS FOR FISHING, CLAMMING OR WATER CONTACT SPORTS

Marin County Health Dept.

This sign is for YOUR protection. It is unlawful to deface it.

Exhibit 10

WARNING

CONTAMINATED WATER

Exceeds U.S. Public Health Standards for Public Use

DO NOT USE

GOLDEN GATE NATIONAL RECREATION AREA

Exhibit 11

Exhibit 12

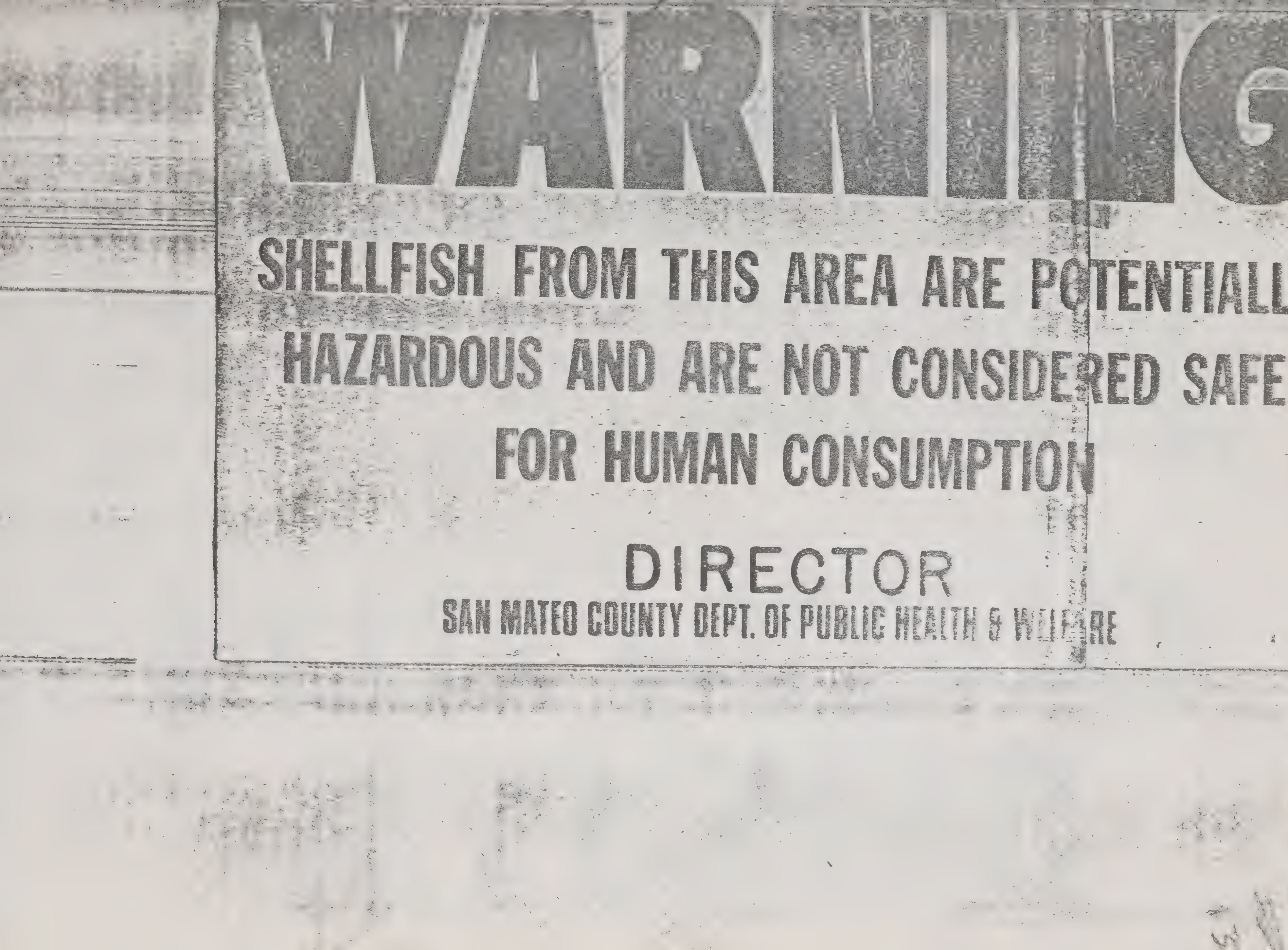

WARNING
SHELLFISH FROM THIS AREA ARE POTENTIALLY
HAZARDOUS AND ARE NOT CONSIDERED SAFE
FOR HUMAN CONSUMPTION
DIRECTOR
SAN MATEO COUNTY DEPT. OF PUBLIC HEALTH & WELFARE

Exhibit 13

WARNING
WATER POLLUTED

The taking of clams, oysters, mussels, or any shellfish for human consumption is prohibited until further notice. This measure has been established to protect the public health.

Marin County Health Department

This sign is for your protection. It is unlawful to remove or de[illegible] it.

Exhibit 14

WARNING

CONTAMINATED FISH

FISH IN THESE WATERS ARE CONTAMINATED WITH DANGEROUS LEVELS OF POISONOUS MERCURY

DO NOT EAT FISH CAUGHT IN THESE WATERS

By order of Santa Clara County Health Department

Exhibit 15

Exhibit 16

WARNING

MUSSEL-CLAM QUARANTINE

NOTICE! A quarantine is hereby established of all Mussels and Clams from this shore of San Francisco Bay. Mussels or Clams are unsafe for human consumption and it is unlawful to take, sell or offer them for sale in or from this designated area.

HOWEVER: Mussels or Clams may be collected and sold as fish bait provided they are broken open and the containers in which these Mussels or Clams are placed are adequately labeled in bold Gothic type letters at least one-half inch as follows:

"FOR FISH BAIT ONLY— UNFIT FOR HUMAN CONSUMPTION"

Said Action is taken for the Preservation of Public Health

by order of

[redacted]

ALAMEDA CO. HEALTH OFFICER

ALAMEDA COUNTY HEALTH CARE SERVICES AGENCY
MUSSEL QUARANTINE ORDER

Exhibit 17

蜆殼類防疫執行通告

(從一九七五年五月一日至十月三十一日有效)

現在衛生部在加省海岸，從奧利根省邊界南至墨西哥邊界為止，包括金山灣，及其他灣區，河口及海港，進行蜆殼類的防疫，在這期間內，蜆殼類會含有对人類有害的毒素。這一防疫令禁止所有上述地點捕捉，售賣及意圖售賣蜆殼類，除非是作魚餌用，作魚餌用的蜆殼類應在售賣，捕獲或未出售時破開。這一點可由地方衛生局自由決定，所有出售作魚餌用的蜆殼類需要盛在容器內出售，容器外要用半吋或以上大字標明。

蜆殼類可能含有毒素—不宜人類進食

所有衛生官員及食物檢查員已接受指示執行此防疫令，從五月一日至十月三十一日為止，這防疫令是為保護大眾健康所設。

鄰近海岸及灣區各縣的衛生官員已將有關的告示貼在顯注的地方。

告示除了通知大家有關防疫令外，還警告大家要將蜆類徹底洗淨後才可以煮食，所有暗色的部份應棄掉，因為從五月至十月出現的毒素多集中在暗色部份中，祇可以進食白色的肉，此外，祇可以在不受垃圾污染的地區捕捉蜆殼類。

衛生總監

WARNING!

MAY 1st---OCTOBER 31st

Mussel Quarantine

From May 1st through October 31st, a Mussel Quarantine order has been established by the California State Department of Public Health and is now effective in Contra Costa County

It Is Illegal to Take, Sell, or Offer for Sale

Mussels from the California coast from the Oregon to the Mexican border, including the waters of the San Francisco Bay, except that permission is granted to take Mussels for use as fish bait, provided that the containers in which these Mussels are placed have been adequately labeled in letters at least one-half inch high as follows:

"For Fish Bait Only–Unfit for Human Consumption"

This quarantine is established for the preservation of the public health and is in addition to those regulations establishing permanent quarantine on shell fish because of sewage pollution.

ALL CLAMS TAKEN BETWEEN MAY 1st AND OCTOBER 31st SHOULD BE THOROUGHLY CLEANED AND WASHED BEFORE COOKING AND ONLY THE WHITE MEAT PREPARED FOR USE. THE DARK PARTS ARE UNFIT FOR HUMAN CONSUMPTION.

This placard is for your protection; it is not to be obstructed, obscured, or defaced in any manner, and may be removed ONLY by the HEALTH OFFICER OR HIS DEPUTIES.

5-73 200 (Rep. 5-67)

Contra Costa County Health

Exhibit 19

WARNING!

MAY 1st - - OCTOBER 31st

MUSSEL QUARANTINE

rom May 1st through October 31st, a Mussel Quarantine order has been established by e California State Department of Public Health and is now effective in Marin County.

IT IS ILLEGAL TO TAKE, SELL, OR OFFER FOR SALE

ussels from the California Coast from the Oregon to the Mexican border, including the aters of San Francisco Bay and all other bays, inlets, and harbors, except that permis- on is granted to take Mussels for use as fish bait, provided that the containers in which ese Mussels are placed have been adequately labeled in letters at least one half inch gh as follows:

Mussels May Contain Poison. Unfit For Human Food

e label should also state: "FOR FISH BAIT ONLY. Do not feed to pets."

s quarantine is established for the preservation of the public health and is in addition to those regulations establishing manent quarantine on shell fish because of SEWAGE POLLUTION.

L CLAMS TAKEN BETWEEN MAY 1st AND OCTOBER 31st SHOULD BE THOROUGH- CLEANED AND WASHED BEFORE COOKING AND ONLY THE WHITE MEAT EPARED FOR USE. THE DARK PARTS ARE UNFIT FOR HUMAN CONSUMPTION.

s placard is for your protection; it is not to be obstructed, obscured, or defaced in any manner, and may be removed ONLY by the HEALTH OFFICER OR HIS DEPUTIES.

MARIN COUNTY HEALTH OFFICER

-65

Exhibit 20

AVISO

1 DE MAYO - - 31 DE OCTUBRE

CUARENTENA DE MEJILLONES

Desde el 1 de Mayo hasta el 31 de Octubre, una orden de cuarentena de Mejillones ha sido establecida por el Estado de California, Departamento de Salud Pública y está ahora en efectivo en el Condado de Marin.

ES ILEGAL COGER, VENDER, O OFRECERLAS PARA VENTA

Mejillones desde la Costa de California desde Oregon hasta el borde Mejicano, incluyendo las aguas de la Bahiá de San Francisco y todas las otras bahiás y puertos, excepto que un permiso se ha dado para coger los Mejillones para el uso de cebo para pescar, con tal que las vasijas en las cuales estos Mejillones se pongan hayan sido adecuadamente marcadas con letras por lo menos de media pulgada de alto, como sigue:

MEJILLONES PUEDEN CONTENER VENENO.
NO ES BUENO PARA COMIDA HUMANA

En la marca también debe decir: "PARA CEBO DE PESCAR SOLAMENTE. No alimente a sus animales domésticos."

Esta cuarentena está establecida para la preservación de la salud pública y está además de aquellas regulaciones establecidas para la cuarentena permanente de los moluscos por la contaminación con las aguas immundas.

TODAS LAS ALMEJAS COJIDAS ENTRE EL 1 DE MAYO Y EL 31 DE OCTUBRE DEBERAN LIMPIARSE COMPLETAMENTE Y LAVARSE ANTES DE COCERLAS Y SOLAMENTE PREPARARSE PARA EL USO LA CARNE BLANCA. LAS PARTES OSCURAS NO SON BUENAS PARA EL CONSUMO HUMANO.

Este aviso es para su protección; no debe ser obstruído, obscurecído, o estropeado en ninguna forma y debe ser removido solamente por el FUNCIONARIO DE SALUD O SUS DIPUTADOS.

CAROLYN B. ALBRECHT, M.D.
Funcionario de Salud del Condado de Marin

San Mateo County Department of Public Health and W[illegible]

225 THIRTY-SEVENTH AVENUE SAN MATEO, CALIFORNIA

WARNING!

MUSSEL QUARANTINE

NOTICE

A quarantine is hereby established of all species of mussels for the ocean shore of California xtending from the California-Oregon boundary south to the California-Mexico boundary, including ne Bay of San Francisco and all other bays, inlets and harbors. This quarantine prohibits the taking, ale or offering for sale of mussels in or from these designated areas, except for use as fish bait. Mussels for use as bait shall be broken open at the time of taking, or prior to sale, at the discretion f the enforcing agency, and shall be placed and sold in containers adequately labeled in boldced Gothic type letters at least one-half inch in height as follows:

MUSSELS MAY CONTAIN POISON
UNFIT FOR HUMAN FOOD

CLAMS

Clams should be cleaned and washed thoroughly and cooked. All dark parts of clams should discarded because the poison when present would be concentrated in the dark parts. Only the hite meat should be prepared for human consumption.

STATE OF CALIFORNIA DEPARTMENT
OF PUBLIC HEALTH

SAN MATEO COUNTY DEPARTMENT
OF PUBLIC HEALTH AND WELFARE

BABALA

MAHIGPIT NA IPINAGBABAWAL ANG KUMAIN NANG ANUMANG KLASE NANG "CLAMS" O "MUSSELLS" NA GALING SA DAGAT NANG PACIFICO O SA MGA HARBOR AT PIER UMPISA SA BUWAN NG MAYO PRIMERO HANGGANG OCTOBRE 31.

WARNING

ADVERTENCIA

NO COMAN CARNE O BEBAN JUGOS DE MEJILLONES, ALMEGAS O SIMILAR CLASE DE MARISCOS DEL MAR, BAHIA, ESTEROS Y PUERTOS DURANTE EL SIGUIENTE PERIODO: 1 DE MAYO HASTA EL 31 DE OCTUBRE.

DO NOT EAT THE MEAT OF, NOR DRINK THE JUICE FROM MUSSELS, CLAMS OR SIMILAR

SHELLFISH

FROM THE OPEN PACIFIC COAST AND ALL BAYS, INLETS AND HARBORS FROM MAY FIRST THROUGH OCTOBER 31st.

SAN FRANCISCO DEPARTMENT OF PUBLIC HEALTH

Exhibit 22

PART II

REPORT TO

ASSOCIATION OF BAY AREA GOVERNMENTS
SAN FRANCISCO BAY REGION

ON

SURFACE RUNOFF MODELING

APRIL 1978

IN SUPPORT OF

SURFACE RUNOFF MANAGEMENT ELEMENT
ENVIRONMENTAL MANAGEMENT PLAN

M&E METCALF & EDDY/ENGINEERS
BOSTON/NEW YORK/PALO ALTO/CHICAGO

IN ASSOCIATION WITH RESOURCE MANAGEMENT ASSOCIATES

CONTENTS

CONTENTS (Continued)

Section 1

INTRODUCTION

In June 1976, the U.S. Environmental Protection Agency awarded a contract to the Association of Bay Area Governments (ABAG) to prepare an Environmental Management Plan (EMP) for the San Francisco Bay Region, under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Surface Runoff Management is one of seven elements of the Plan.

The planning area represented by ABAG covers 5,000 square miles, 80% of which drains directly into San Francisco Bay or its immediate tributaries. By 1977, the area was home for 4.9 million residents, up 5.5% from 1970 and 83% from 1950 when the first attempts at comprehensive water quality protection were initiated.

That much remains to be done is evident from the following quote from the 1974 comprehensive Water Quality Control Plan - San Francisco Bay Basin, California [1.1]*.

> "While California is endowed with more water of good quality than many regions of the nation, the compound effect of increased use of water and increasing volume and strength of municipal, industrial, and agricultural wastes have degraded or threatened water quality in many areas of the state. In San Francisco Bay, for example, dissolved oxygen levels in the southern extremities of the system are depressed considerably below natural values; shellfish harvesting has all but been eliminated within the Bay, and recreational uses along the bayshore of the San Francisco Peninsula are not permitted during portions of the year due to bacteriological contamination from untreated wet weather discharges."

Is the role of surface runoff significant in the observed water quality of the Bay and its immediate tributaries? Yes, but there are uncertainties [1.1].

> "Nonpoint source waste loads, unlike point source wastes, cannot be readily quantified through flow measurement and sampling and analysis techniques. It is necessary, therefore, to calculate such waste loads from land use data, quantities of applied irrigation water, surface runoff, etc.

*References are listed in Appendix A.

The major portion of nonpoint source waste loads is that from stormwater runoff. Waste loadings from other diffuse sources represent only a small portion of the total load and are difficult to analyze and control.

...Data reviewed in the Basin Plan study indicate that urban and nonurban runoff contribute a significant amount of pollutants. Although management of runoff poses unique problems, control measures for nonpoint sources are possible. Bacteria are the major constitutent of concern from wet weather overflows. Future control actions must principally concentrate on reducing the public health hazard associated with high bacterial concentrations which can adversely affect water related recreation and shellfish harvesting. Such beneficial uses also require elimination of physical evidence from untreated wastewater in nearshore and shoreline waters."

PURPOSE AND SCOPE OF PROJECT

The Surface Runoff Management element of the EMP addresses problems caused by pollutants* washed from the surface of the land in urban and rural areas. It is a composite of eight local Surface Runoff Control Plans formulated by each county in the region (with the exception of San Francisco, which had previously formulated a plan) with coordination, technical assistance, and regional integration by ABAG. Greater emphasis is placed on urban runoff in most areas because the problems are believed more acute and better subject to mitigation. Preference is given to near-term control measures that can be implemented at low cost and in a relatively short period of time (e.g., detention, street sweeping, etc.) [1.2].

---

*Several counties have taken exception to the term "pollutant" and would prefer the use of "contaminant" unless the existence of an adverse effect has been proven. In California law, "contaminant" is defined specifically as being related to public health, whereas "pollutant" is a more general term implying nonpublic health water quality degradation.

Consultant services provided by Metcalf & Eddy, Inc. and Resource Management Associates, Inc. (M&E/RMA) are delineated by Contract Agreement executed August 30, 1976, between ABAG and Metcalf & Eddy and include the following major activities [1.3].

Provide technical assistance for analyzing the quantity and quality of surface runoff, and for evaluating the impact of various control measures and projections of urban development through

- Setup and user documentation of mathematical models for surface runoff
- Continuous program assessment and updating in consultation with ABAG staff
- Continuous guidance to county lead agencies in model application for effective control plan development
- Evaluation of present and projected pollutant washoff by surface runoff
- Evaluation of alternative control measures
- Preparation of final report summarizing the work accomplished

The output shall be transferable for receiving water model input and emphasis is to be placed on near-term control measures that can be implemented at low cost and in a relatively short period of time.

PURPOSE OF THIS REPORT

The purpose of this report is to summarize the mathematical modeling work accomplished in support of the Surface Runoff Management element of the EMP and to provide a compact reference base for future work. The report should not be interpreted as a surrogate analysis of surface runoff problems and solutions within the Bay Area since it has been developed independent of the reviews and critiques necessary to such analysis.

Data reported herein are believed current for the time that a particular activity was accomplished and may differ from subsequent data due to refinements made in finalization of individual plans. Also, regional analyses are projected from a standardized quality data base in the belief that

sufficient data do not yet exist to substantiate a county-by-county variability in unit assumptions.

FORMAT OF PRESENTATION

The format of this report generally follows the chronology of assistance given to the counties during the course of plan development. In Section 2, the study area is defined; concepts and problems specific to surface runoff analysis and control are introduced; and the dual model approach selected is described. In Section 3, details on the model structures, operations, and utilization are presented. In Section 4, the specific application of the models in San Francisco Bay study area is discussed including data development, model calibration, and mitigation measure and receiving water impact simulations. In Section 5, a brief overview of program results is presented along with the sensitivity of the results to assumptions for selected parameters. Conclusions and recommendations with respect to continuing programs are presented in Section 6.

To facilitate information retrieval, workshop documents and computer program code and data set identifiers are listed in the appendix. The reader is referred to the workshop documents for more detailed presentations and user instructions.

ACKNOWLEDGMENTS

The assistance of ABAG and County Lead Agency staffs in the direction and cooperative development of this project are gratefully acknowledged. Particular acknowledgment is directed to ABAG's Dr. Yoram J. Litwin, Program Manager for surface runoff planning, and to Dr. William J. Miller, 208 Program Coordinator.

Key participating technical staff of the County Lead Agencies, Metcalf & Eddy, and Resource Management Associates are listed in Appendix A.

Section 2

STUDY AREA AND APPROACH CONCEPT

San Francisco Bay is by far the dominant hydrographic feature of the study area. It is also the "end of the pipe" receptacle of all treated and untreated wastewater discharges of the region and, as such, it is a constant reflection of both good and bad wastewater management practices exercised at all levels of government, both within the region and over the full extent of the great Central Valley which drains into the Bay.

In this section, the study area characteristics are highlighted and defined; concepts of surface runoff analysis and control are introduced; and the adopted dual model approach is described.

STUDY AREA CHARACTERISTICS

The study area boundary of ABAG's water quality planning jurisdiction is defined in Figure 2-1. The geographic center is close to Danville in Contra Costa County, and the population center is near San Leandro in Alameda County and moving southward under development spurred by Santa Clara County's Silicon Valley technology.

San Francisco Bay

The surface area of San Francisco Bay, including the interconnected San Pablo and Suisun Bays, is 435 square miles [2.1] or just under 9% of the total study area. Significantly, filling and commercial development reduced the surface area to 60% of its predevelopment (1850) size before strict controls were adopted and enforced over the last 2 decades. The volume of the Bay is approximately 1,570 billion gallons plus a tidal prism of 375 billion gallons. The net beneficial exchange with the Pacific Ocean (Bay volume replaced by "unpolluted" ocean waters) is 90 billion gallons per tidal cycle or 180 billion gallons per day. Representative flow volumes, which to a large extent control the dynamics and water quality of the Bay, are shown in Table 2-1.

The role of ocean exchange is dominant in the waste assimilative capacity of the Bay and capacities appear to decrease markedly with increasing distance from the Golden Gate.

FIGURE 2-1. STUDY AREA

Table 2-1. ESTIMATED ANNUAL EXISTING FLOWS TO SAN FRANCISCO BAY [2.1]

Source	Net flow per year, billion gallons
Beneficial ocean exchange	65,700
Delta outflow	4,900
Point discharges	240
Surface runoff	400

The quality of Bay waters reached a nadir in the early 1950s when decades of decline were finally stemmed and reversed, due largely to state water pollution control legislation that forced the treatment of municipal and industrial wastewaters. Thereafter, steady improvement was noted even in the face of rising population in the Bay Area. By the early 1970s, the quality of Bay waters in many locations was more acceptable for beneficial uses than at any time in over 50 years. As area growth expands, continuation of water quality improvements appears today to be dependent on gradual upgrading of treatment and improved management of surface runoff and other diffuse sources.

Watersheds

Surface runoff, quantity and quality, is influenced by topography, soil types and land cover, the types and intensity of development, and the extent to which management practices are applied and enforced. Among these, urbanization and sanitation practices are perhaps the most significant in the study area.

The Association of Bay Area Governments reports the amount of urbanized land in the study area has grown from 42 square miles in 1852 to about 1,300 square miles today. Preferences for the suburban life style have been predominant over the last 3 decades leading to a rapid consumption of open space in an every-increasing urban sprawl and resulting in lowered population densities in older, core cities and booming demands for transportation arteries and dispersed services in the developing areas. Heavy industries (predominantly petro-chemical) are generally limited to the North and Central Bay drainage areas of Contra Costa, Alameda, and portions of Solano counties. The three northern counties--Marin, Sonoma, and Napa, are principally

agricultural and residential, as are southern portions of Santa Clara and eastern Alameda and Contra Costa counties. Aerospace and electronics are principal industrial activities in northern Santa Clara and San Mateo counties.

The population of the area is expected to grow from a present (1978) 4.9 million to between 5.4 and 6.1 million by the year 2000 [2.1], a comparatively modest rate of 25 to 50 thousand persons per year. Assuming family units at 2.5 persons and a preference for single family (10,000 square foot) home sites including streets and services, the urbanized residential area could grow at a potential average rate of 3.5 to 7.0 square miles per year. Increases above this rate could be generated by a continued migration from densely developed urban areas to the suburbs and by the location or relocation of job producing industries within the study area.

Climate

Rainfall and possibly wind (for the airborne distribution of particulates) are the climatic features of interest for surface runoff. Lines of equal average annual rainfall over the study area are shown in Figure 2-2. The northern, coastal, and higher elevation areas typically have higher volumes of rainfall with a relatively linear decrease experienced with movement to the south or east.

Winds are predominantly out of the west and are highly influenced by topography as they seek out least resistant passages to the east, e.g., Carquinez Strait, Altamont Pass, etc.

CONCEPTS OF SURFACE RUNOFF ANALYSIS AND CONTROL

Surface runoff generated problems and appropriate mitigation measures are difficult to assess because:

- The events are irregular and unpredictable;
- The impacts are likely to be highly variable in time and location;
- Other discharges or conditions tend to mask actual impacts;
- Relatively little usable data are available and new data are extremely time consuming and costly to obtain;

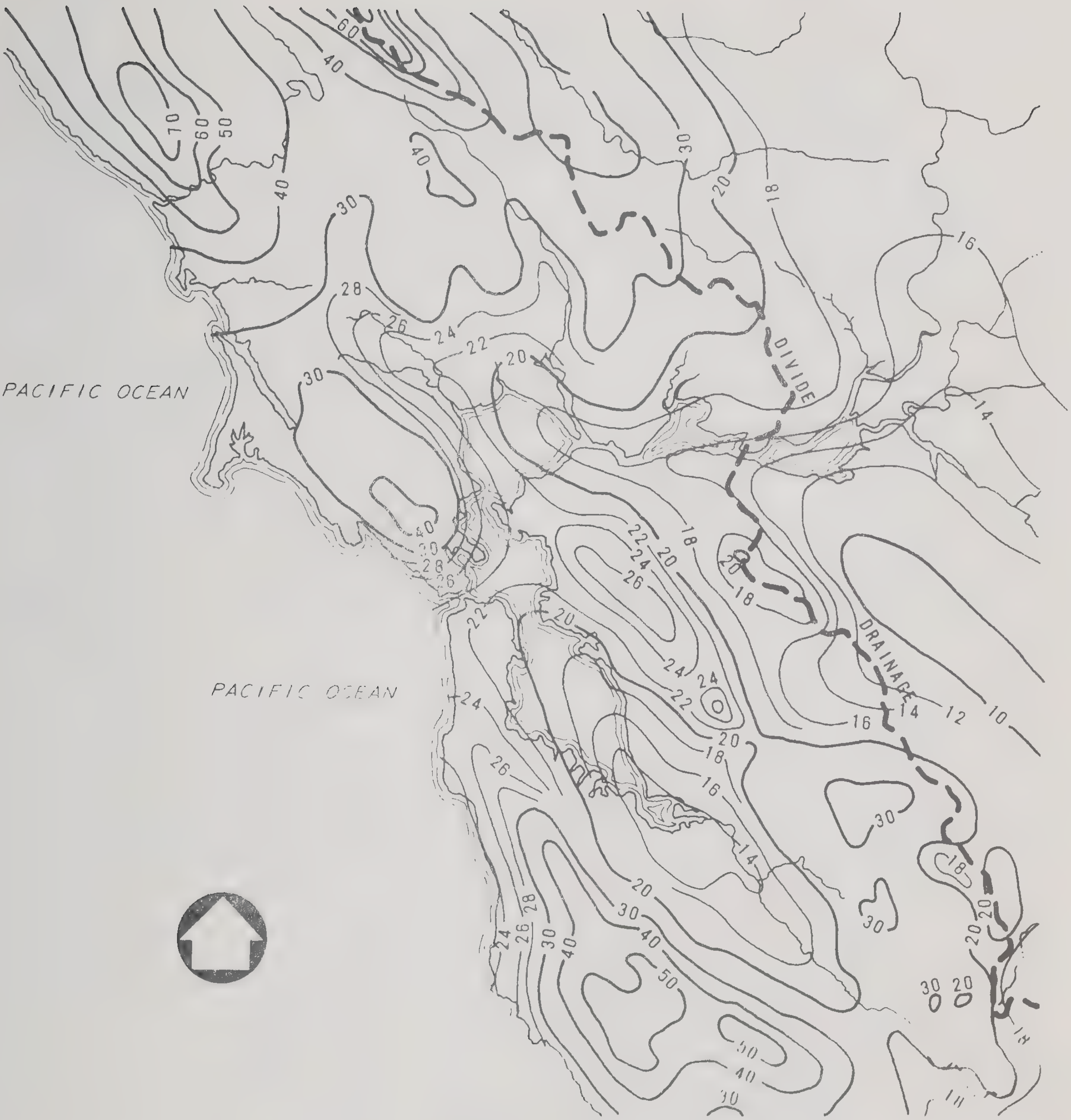


FIGURE 2-2. AVERAGE ANNUAL RAINFALL LINES

- Mitigation measures are largely conceptual and effectiveness is ill-defined; and

- Objective effluent criteria have not been specified (e.g., no waste load allocations have been set aside for surface runoff pollutants by receiving water segment).

Surface runoff problems involve three types of discharges: (1) combined sewer overflows, (2) surface runoff either collected separately or occurring as nonsewered runoff, and (3) overflows of municipal wastewater resulting from excessive inflow/infiltration.

Of the three types of discharges, the combined sewer overflows and overflows of infiltrated municipal wastewater have similar characteristics, with 5-day biochemical oxygen demand (BOD_5) loadings averaging approximately one-half the strength of *untreated* domestic sewage. This contrasts with surface runoff from urban areas which generally has a BOD_5 approximately the strength of secondary effluent [2.2].

The major constituent of street runoff has been found to be suspended and settleable solids--primarily inorganic, mineral-like matter, similar to sand and silt. Along with this material there are organic matter, algal nutrients, coliform bacteria, heavy metals, pesticides, and a host of lesser compounds at such low concentrations they are difficult to identify and quantify. Significantly, most constituents are largely concentrated in the very fine material (<43 microns) limiting the pollution abatement effectiveness of conventional street sweeping operations and catchbasins [2.2].

Bacterial contamination of diluted overflow from combined sewer systems is "typically" one order of magnitude lower, and urban runoff two to four orders of magnitude lower, than that of untreated municipal wastewater. Significantly, however, the concentrations are two to five orders of magnitude *higher* than those considered safe for water contact activities [2.2] and may, on occasion, be comparable to primary treated wastewater.

Much less is known about the quality of runoff from undeveloped areas, but with the exception of high solids content from erosion it is generally believed to be relatively free of pollutants.

In the study area, only San Francisco and small portions of Oakland have combined sewers; and excessive inflow/infiltration is largely limited to the older urban core areas.

Program Elements

The key program elements, which, working in combination, are used to produce the surface runoff management plans, are shown with their conceptual interrelationships in Figure 2-3. The mathematical models for which M&E/RMA are responsible are shown shaded. Basically, the models are used to compute and aggregate loadings which can then be compared to other point and nonpoint discharges to common segments of the receiving waters. The loadings are the products of flow and concentration and are expressed in average pounds per day over a specified time period.

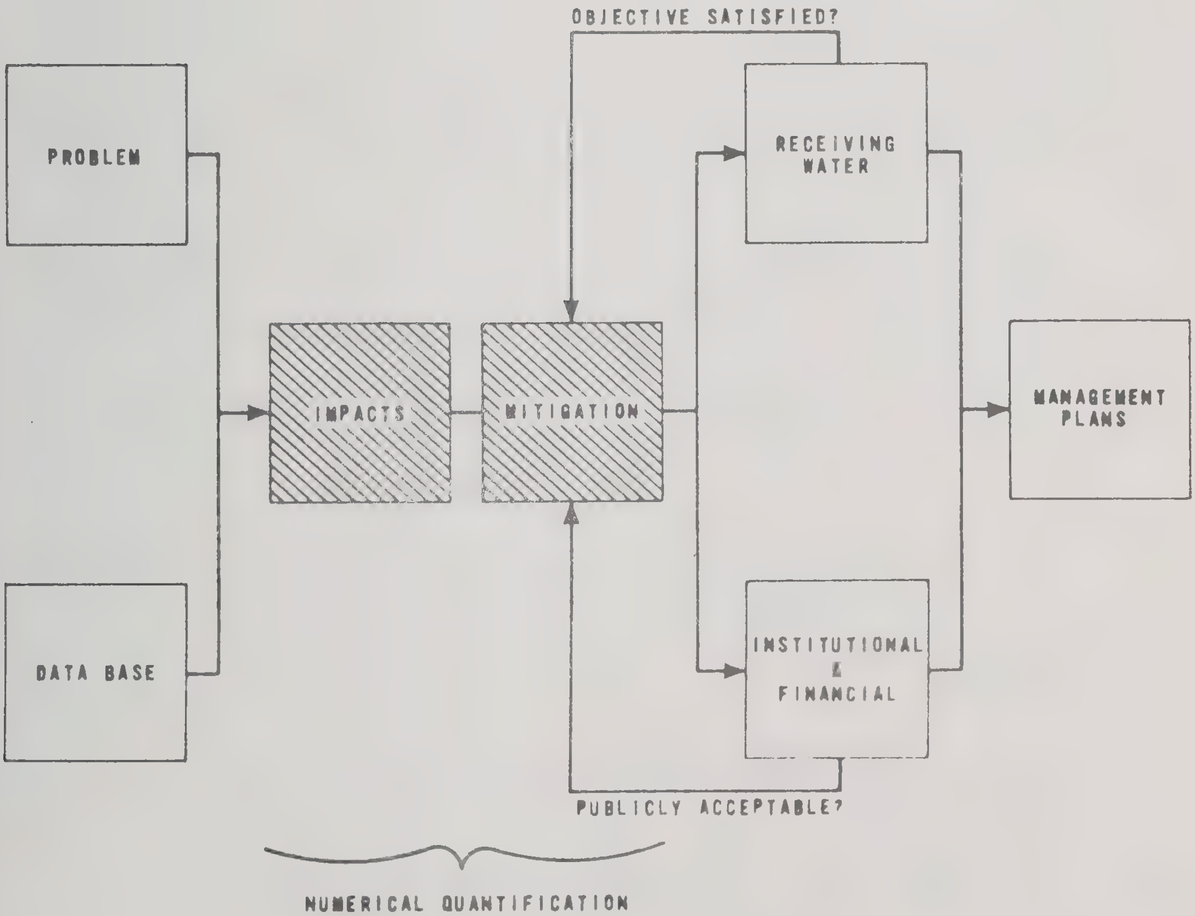


FIGURE 2-3. PROGRAM ELEMENTS

The mitigation measures, if effective, reduce these loadings a certain amount associated with a determinable cost investment. The reduced loadings are applied in the receiving water analysis (by others) to determine if water quality criteria are satisfied or, if not, the extent of violation. Similarly, the costs can be evaluated for institutional and financial practicality and the measure itself for public acceptance. Feedback from both cost and impact can be used to adjust the level to which the mitigation measure is applied.

Obviously, the better the problem is defined, the more specific and accurate will be the assessment. Similarly, the more complete and correct the data base can be made, the better the modeling estimates and calibration will become. In the absence of local data (as is the case initially, with most quality constituents), regional and national data are substituted.

Control Measures

Forty-two potentially applicable surface runoff control measures were inventoried by ABAG and grouped into four general categories as follows:

- Group A--Measures to reduce the accumulation of pollutants prior to runoff. This category includes alternatives designed to remove pollutants from land surfaces by actions such as street sweeping or stormwater collection system cleaning and alternatives designed to prevent deposition by controlling dumping or removing sewage cross-connections.

- Group B--Measures to control land use. The various options for the control of land use are based on the fact that urban growth increases surface runoff and pollution. Regulation of the density and location of urban growth will be an alternative control measure.

- Group C--Measures to reduce the amount of pollutants and the peak flow or volume of runoff. The alternatives in this group can be thought of as onsite control. The pollutants and as much rainfall as possible are held back in the upper watersheds. The pollutants can be controlled by erosion prevention practices such as applying vegetative cover or proper construction practices. The volume of runoff is decreased by alternatives that maximize the pervious area and infiltration capacity of the basin.

- Group D--Measures to treat and store runoff. The emphasis of the areawide waste management planning study is on alternatives that are cost effective and not capital intensive. Group D includes alternatives that treat stormwater runoff after it reaches the collection system and will require the construction of capital intensive structures. The options can be categorized as online or offline storage and treatment units.

Details on these options [2.3] and other candidate measures with particular applicability for open space and agricultural runoff [2.4] were made available to the county lead agencies through mailings and workshops.

Relevance of Modeling

Mathematical models are simply a means to link cause-effect relationships quantitatively. Models follow operating rules without exception or interpretation, and can process mountains of data with relative ease. The model developer sets the rules (and in most cases, the options), and the user furnishes the data and receives the results.

Fundamentally, surface runoff models utilize rainfall records, surface catchment descriptions, and defined transport-treatment networks to produce loadings or continuous discharge records to receiving waters. The great utility of models as a tool for investigation lies in the ease with which one may examine large numbers of complex alternatives. Given that the model can once be made to represent prototype behavior with reasonable reliability, then the user can apply it repetitively to test a wide range of suggested solutions to specific stormwater problems [2.5].

What are the alternatives to modeling? Basically, the alternatives reduce to observations (field surveys, monitoring, etc.); interviews (what does the public sense the problem to be, and why); and speculation. While these items are ideal in a support role, when they become the primary control they invariably introduce ambiguity, inconsistency, and abstraction. For example, when an observer views a condition in a stream, is that observation representative of what it would have been a week ago? A year ago? Ten years in the future? A mile downstream or upstream? A parallel stream a mile away? How then can he arrive at conclusions and, if he does, would another observer make the identical interpretation?

Mathematical models can avoid or minimize many of these problems and can benefit from the collective efforts of all observers, both within the study area and nationwide, as well as provide a base for continuing programs. For these reasons and other considerations such as time, budget, and weather dependency, models are fundamental to the surface runoff program.

DUAL MODEL APPROACH

The technical approach adopted for the ABAG surface runoff program involves two levels of modeling analysis. The first, the Macroscopic Planning Model (MAC) looks at broad areas and long periods of record. Precision is sacrificed for breadth of coverage and for speed and flexibility in model application.

The second, the Storm Water Management Model (SWMM), is far more detailed and both site and storm specific. Thus, it is best applied for relatively small watersheds, on the order of 1 to 10 square miles, where specific control measures are to be assessed. The models are used interactively, with MAC identifying the relative importance of major watersheds toward specific problems, and SWMM providing the detailed examination and in turn outputting data which can be used to improve the MAC assumptions.

Details of these two models are discussed in Section 3 along with the introduction of the receiving water simulator.

Section 3

MATHEMATICAL MODEL DESCRIPTIONS

Mathematical models have been shown to be essential to the understanding and representation of the randomness and time variability of surface runoff events. The model objective is to quantify the probable impacts of growth characteristics, land use, and management practices on the quantities and qualities of surface runoff and the potential consequences of these impacts through simulated changes in the receiving waters of San Francisco Bay (or in intracounty lakes and streams).

In this section, the two surface runoff models and the coarse network receiving water simulation model are described.

MACROSCOPIC PLANNING MODEL (MAC)

MAC is a special purpose, continuous simulation model employing simplified techniques for representing prototype behavior [3.1] and adapted for the ABAG-208 analysis by Metcalf & Eddy. The input data requirements are minimal; the areal and temporal coverage is broad; and the model is both flexible and easily applied.

The purpose of MAC is to identify and project surface runoff loadings to San Francisco Bay and/or interbasin transfers with both time and location as variables. Loadings can be computed under present, past, and projected conditions and can be modified by development patterns, population growth, applied mitigation measures, and probabilistic storm patterns.

Model Concepts

The model has as its foundation the so-called "rational method" which relates runoff rate to drainage area, intensity of rainfall, and perviousness of the surface. It is an established tool for the analysis of runoff. The simple equation that states the runoff relationship, when coupled with load computations for several constituents and analysis of multiple land uses, becomes a continuous simulation model that provides useful, understandable results.

Rainfall is the driving variable of the model. In fact, it is the only input variable which changes during each time step, generally 1 day intervals, of the simulation. User

specifications in terms of catchment descriptions and land use associated quality parameters control the conversion of rainfall into runoff quantity and quality. The runoff, in turn, may be operated on by user specified storage and treatment relationships to produce a net discharge output to the receiving water. The output may be entirely overflow (no treatment), entirely treated effluent (all runoff processed), or a mixture of both. The interrelationships are shown in Figure 3-1.

Description

MAC, like any computer program, has three distinct phases--data preparation, run execution, and output analysis. The first and last phases are very important because engineering judgment is used to translate the real world into numbers and then the numbers back to the real world.

Data Preparation. There are five major areas of data preparation for MAC--subarea definition, area characterization, runoff quality characterization, rainfall specification, and storage-treatment simulation.

Subareas. Subareas are the actual units the model analyzes. These units provide a geographic area that can be focused on as a potential pollution source.

In the ABAG analysis, two divisions were made as illustrated in Figure 3-2. First, the entire region was broken into "major watersheds." These major watersheds generally align with hydrographic boundaries. The second division was into subareas. The subareas only very generally conform to hydrographic boundaries and in some cases are not even contiguous. The areas are selected to reflect general land use and development patterns. Idealistically, the first and usually geographically highest area, (A), is labeled natural or protected; the second area, (B), often rolling hills and agricultural land, is labeled potentially developable; and the third area, (C), the currently developed area, is labeled existing urban. Subarea ties to specific land use and demographic models are discussed in Section 4.

Area Characterization. Each subarea is characterized by two terms: the "K" factor and the area for each land use in a subarea. The "K" factor or "gross runoff coefficient" is a number that reflects the average annual runoff divided by the average annual rainfall. Computationally, this term is similar to "C" in the rational method. The second term is simply the area of land in acres for a particular land use. It is very important that the land use classifications be broad enough to include all of the land in a particular subarea.

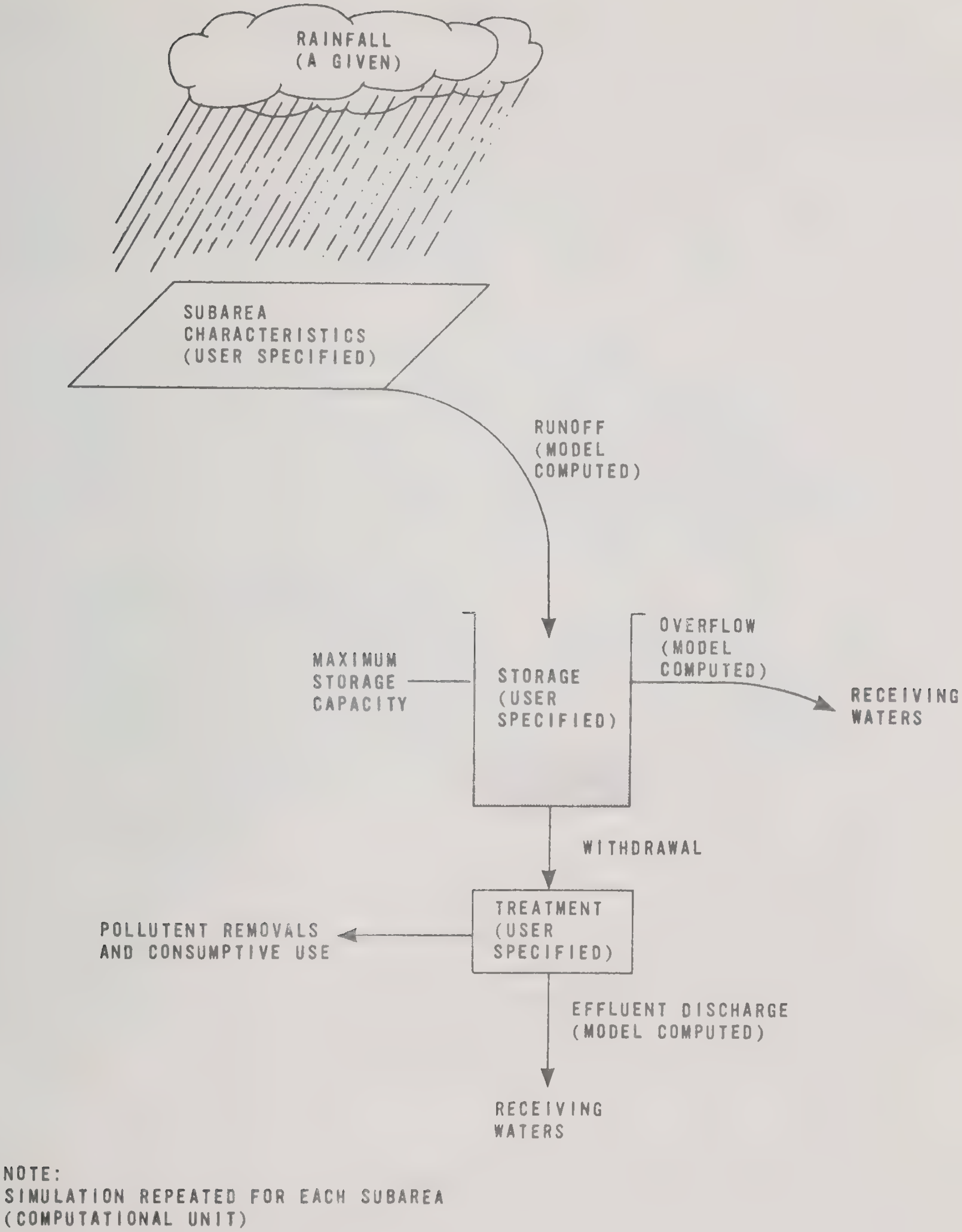


FIGURE 3-1. SCHEMATIC REPRESENTATION
OF MAC CONCEPT

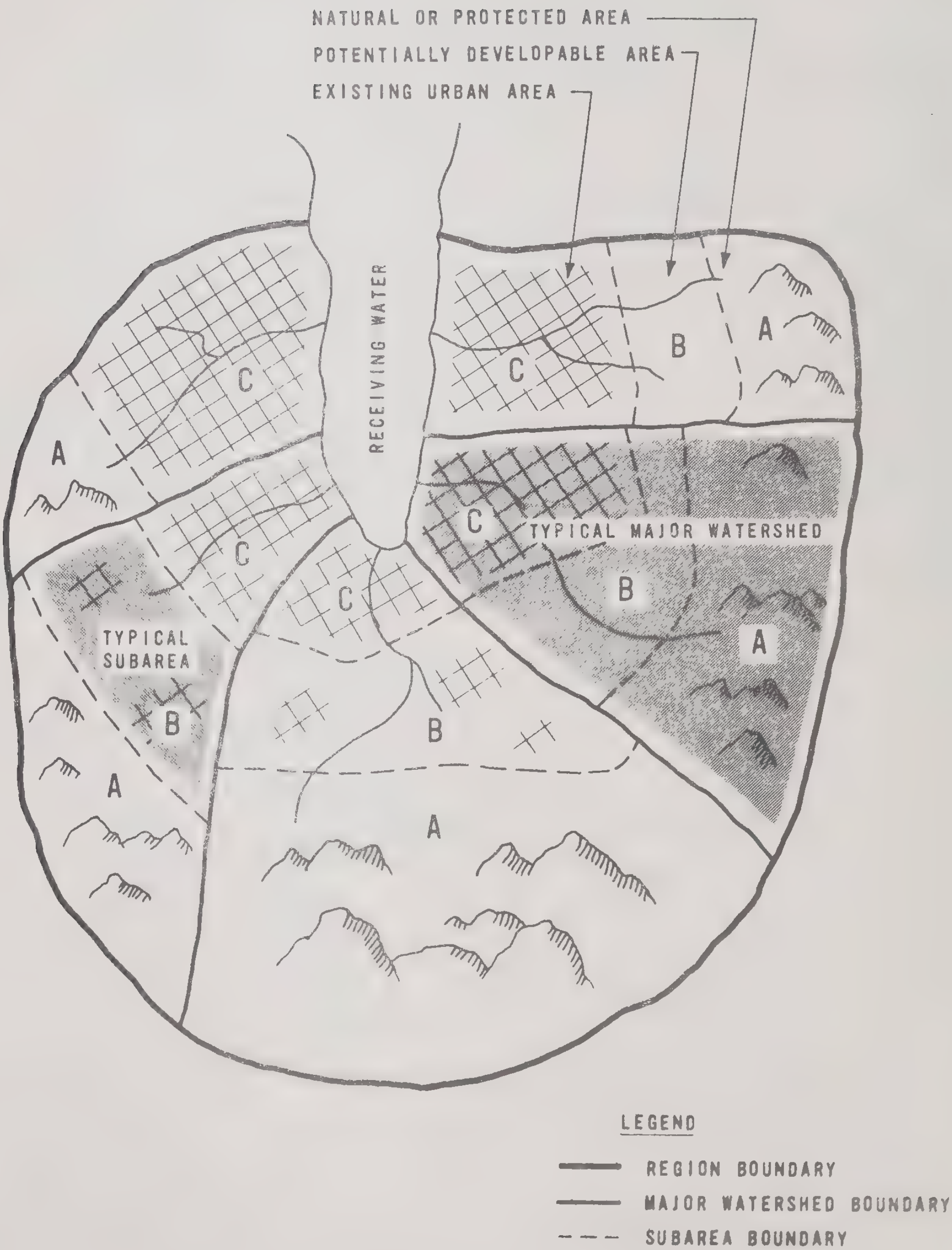


FIGURE 3-2. IDEALIZED DIVISION OF WATERSHEDS

Runoff Quality Characteristics. The quality of the runoff in mg/L for each land use is also an input to the model. Ideally, this information should be developed from local sampling programs. In lieu of local data, national sources can be used. Since only limited data for discrete land uses have been obtained over the years and precisely uniform land use conditions do not exist, these must be used with caution. The national data are sufficiently accurate, however, to indicate trends and order of magnitude comparisons for urban land uses. Typical concentrations are reported in Section 4.

Rainfall. Rainfall records in inches/hour and inches/day are among the most significant variables in the model. A long historic record is required. A daily rainfall file of from 10 to 25 years usually provides the best analysis. Data collected by the U.S. Department of Commerce National Climatic Center is complete and compatible with the model. The Department of Commerce data are collected on computer tapes for most primary gages across the country.

A rainfall factor is included in the model to transpose rainfall from the primary gage to the area being analyzed. This factor can be computed using an isohyet map such as provided in Figure 2-2. By use of the transfer factors, nine primary rain gage records (an average of one per county) were found sufficient to cover the full study area within the expected tolerance of the analysis.

Storage-Treatment. Storage-treatment relationships are used to simulate reservoirs, existing or proposed, within the subareas and to simulate proposed mitigation measures. The user must specify a maximum storage volume (zero volume acceptable if the storage effect is to be totally ignored) above which runoff flows will bypass unchanged and a uniform treatment rate that allows a continuous reduction of storage or runoff with user supplied quality changes.

Run Execution

All of the data that are collected for each subarea--"K" factors, areas for each land use, quality constants by land use, and rainfall records--are input into the computer in a specified format. Either computer cards or interactive terminals can be used to initiate a run of the program which has been written in Fortran IV. The program has been used on a variety of different computers ranging in size from an IBM 1130 and a Xerox 560 to a CDC 7900 and an IBM 370/168.

The program logic is shown by an outline flow chart in Figure 3-3. Formats for input data cards are provided in Appendix D.

To use the model to evaluate a mitigation measure, it is necessary to modify one or more of the model's input parameters. For example, to evaluate the effectiveness of street sweeping in a commercial area, the value for concentration of suspended solids in commercial areas might be reduced by 40% and a model run performed using this new value. The mass loading of solids from the basin would then be compared to the option of no street sweeping.

The model inputs that are subject to modification include:

- "K" the gross runoff coefficient of runoff/rainfall for a specific land use
- "C" the concentration of a specific pollutant for a specific land use
- The fraction of total land allocated to each specific land use
- The storage subroutine that modifies rate of runoff but not volume
- The treatment subroutine that reduces the pollutant loading simulating a structural treatment alternative

Output Analysis

The program provides two major outputs, an "echo" of the input data and a display of the computation results.

The first output page summarizes all of the input data with the exception of the rainfall records. Only the data displayed on this sheet are used in the computations. The program does not include any default values or hidden variables.

The second and following pages of output summarize, with monthly and yearly totals, the computations that have been performed. The computations are actually made on a daily basis and only the monthly totals are printed. The program also has a daily print option which displays details that have been summarized by month.

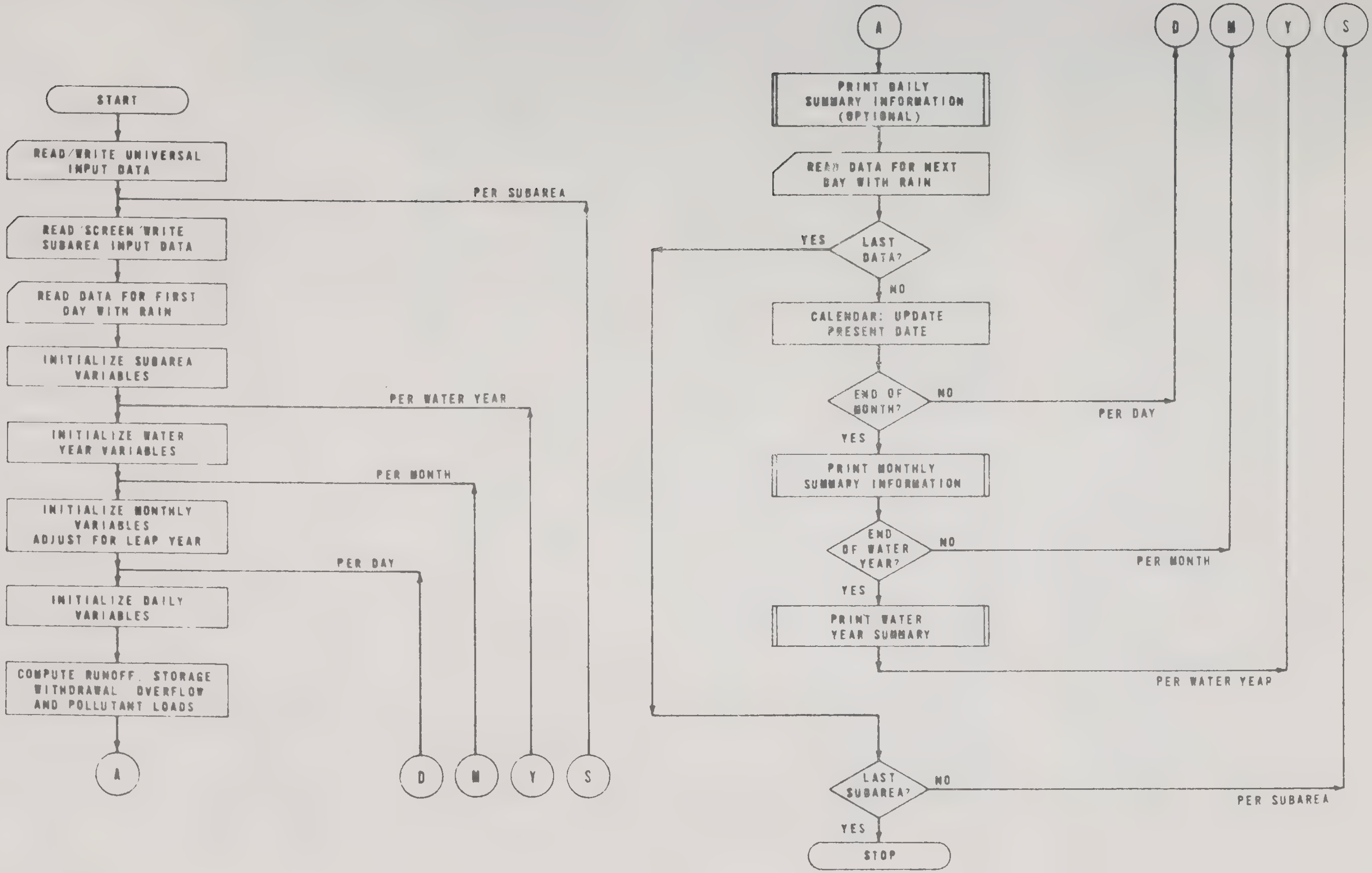


FIGURE 3-3. SIMPLIFIED FLOWCHART FOR MAC

At this point, the analysis falls back into the hands of the engineer to interpret and utilize to his best advantage. One of the possible uses is to indicate graphically the areal distribution of loads on the receiving water or, if desired, to continue the analysis through receiving water simulation. The stormwater pollution from a major watershed can also be compared with a point source discharging from the same area to see the relative size of the loadings. Bar graphs have been used effectively for this comparison.

SITE SPECIFIC MODEL (SWMM)

The second and complementary model used in the ABAG surface runoff program is characterized as a design or site specific model. The differences between planning and design models are found in their level of approximation of physical systems and the time span over which they operate. Typical planning models have a relatively low degree of physical resolution and operate over long time spans whereas site specific models provide much higher physical resolution and use shorter time horizons.

EPA's Storm Water Management Model (or SWMM pronounced "swim") was selected to fill the detailed needs for demonstration site applications and to provide guidance in parameter selections for the broader planning model. The model was adapted for the ABAG-208 analysis by Resource Management Associates. The complete SWMM model uses a digital computer to simulate the dynamic history of stormwater quantity and quality based on rainfall and pollutant inputs. The model has the capability to route both flow and pollutants across the land surface, through a system's conveyance and storage/treatment facilities, and into a receiving water. The site specific model discussed here refers only to that portion of the SWMM model which simulates flow and quality behavior in the surface drainage system.

Model Description

The site specific model simulates runoff quantity and quality from a drainage basin for a given rainfall pattern. The inputs to the model are the rainfall pattern and the configuration and characteristics of the drainage basin; the outputs are time histories of runoff quantity and quality at preselected locations within the basin.

In order to simulate an actual drainage system, the real basin must be conceptually represented by a mathematical abstraction of hydraulic elements which include

subcatchments, gutters, and pipes. Each of these elements is then characterized by appropriate parameters such as area, slope, and roughness. For the purposes of the model, a subcatchment is considered to be rectangular in shape with reasonably uniform characteristics. The geometry of a subcatchment is defined by the area, width, and ground slope. The type of ground cover determines the detention depth requirements, the surface roughness, and the coefficients describing the infiltration loss by an exponential function. The subcatchments need not be the same size, and irregular shapes can be approximated by equivalent rectangles. In principle, a series of subcatchments can be designed to cover an entire drainage basin.

The subcatchments form an aggregated system of gutters and pipes by specifying the connectivity of flow. Hydraulically, gutters and pipes are described by the Manning's coefficient, length, invert slope, and shape. The latter may include the bottom width and side slopes for rectangles, trapezoids, and triangles and the diameter for circular pipes.

A typical but idealized drainage system is shown in Figure 3-4. As shown, subcatchment 2 drains into gutter 1. Both gutter 1 and subcatchment 1 discharge into gutter 2. Several subcatchments and gutters can be connected to a given gutter, depending on the topographic condition.

The runoff quality components of the SWMM model evolved over a period of years from studies in Cincinnati, Chicago, San Francisco, and a number of other cities [3.2]. The model considers the related processes of pollutant deposition and production occurring before or during a storm, and pollutant washoff and transport occurring during a storm. These processes are treated somewhat differently for urban and rural areas, although many of the fundamental principles involved are similar.

The quality model relates all pollutant concentrations to suspended solids levels, since several studies have shown that many of the pollutants of concern (BOD, heavy metals, etc.) are carried with suspended material. Also, many surface runoff control measures, such as street sweeping, directly affect suspended solids making this constituent a useful one to emphasize.

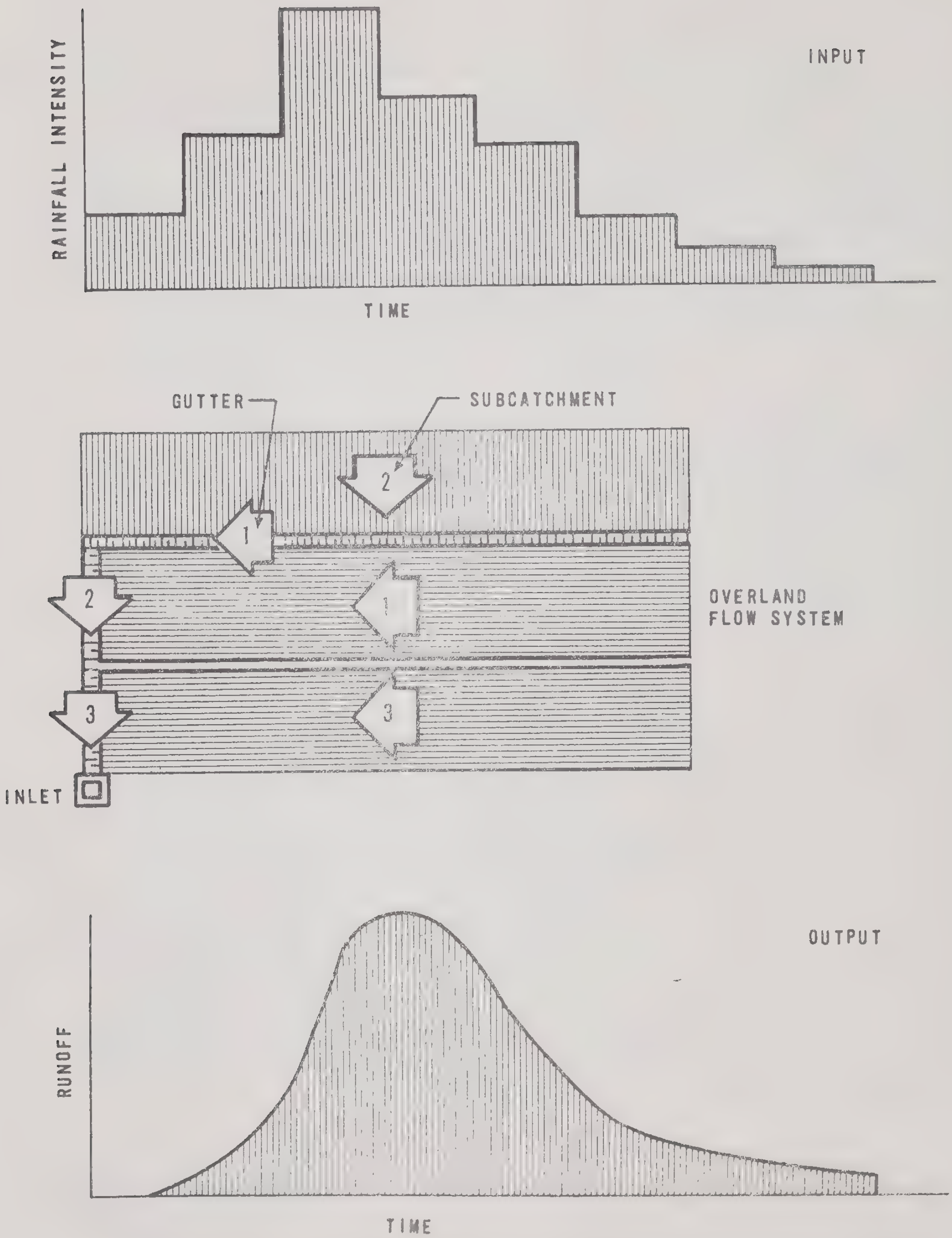


FIGURE 3-4. SCHEMATIC REPRESENTATION OF SWMM CONCEPT

The ABAG version of SWMM includes the following types of land use:

- Single family residential
- Multiple family residential
- Commercial
- Industrial
- Undeveloped or park lands

Each of these land uses generates or accumulates suspended solids in a particular manner, reflected by unique accumulation functions. Combinations of several land uses in a particular watershed will generate a unique suspended solids "signature" for that watershed. Once the total watershed suspended solids level has been computed, weighting factors are used to derive other pollutant concentrations (such as BOD, nutrients, heavy metals, etc.).

In urban areas, suspended solids carried during storms result primarily from the dust and dirt accumulation which takes place between storm events. The site specific model computes this accumulation in a straightforward manner related to the number of dry days prior to the storm event being simulated (specified as an input). The daily accumulation is modified by street sweeping, as described by the number of days between cleanings, and the number of passes per cleaning made by the street sweeper. The default pollutant accumulation rates between street sweeping passes in SWMM are based on the studies made by the American Public Works Association in Chicago [3.3]. Industrial areas tended to provide the largest amount of street litter. Commercial areas tend to generate a somewhat lesser quantity of dust and dirt than industrial areas, but higher than residential areas. Residential areas tended to show increasing amounts of dust and dirt as the population density increased, reflecting the increased usage made of the street by pedestrians and vehicles. SWMM computes pollutant washoff in urban areas from a relatively simple exponential washoff function which assumes that the washoff rate is proportional to the amount of accumulated material remaining on the ground at any time during a storm and to the rainfall intensity.

In rural areas, suspended solids do not accumulate in the same way as in urban areas; rather, they are generated primarily by erosion which occurs during the storm. Since rainfall both generates and washes off suspended material in rural watersheds, it is appropriate to combine these two

functions in a single equation--the well known Universal Soil Loss Equation (USLE).

The USLE was derived from statistical analyses of soil loss and associated data obtained in 40 years of research by the Agricultural Research Service, which was assembled by the Runoff and Soil Loss Data Center at Purdue University. The data include more than 250,000 runoff events at 48 research stations in 26 states, representing about 10,000 event-years of erosion under natural rain. The USLE was developed by Wischmeier and Smith [3.4] as an estimate of the average annual soil erosion from rain storms for a given upland area, expressed as the average annual soil loss per unit area.

The USLE represents the most comprehensive attempt to date at relating the major factors in soil erosion. It is used in SWMM to predict the average soil loss for a given storm or time period. It is recognized that this equation was not developed for making predictions based on specific rainfall events. There are many random variables which tend to cancel out when computing annual time averages which may actually be significant when predicting individual storm yields. The initial soil-moisture condition, for example, is a parameter which cannot be determined directly and used reliably. It should be understood by the user that the USLE enables planners to estimate and compare gross erosion rates for a wide range of rainfall, soil, slope, crop, and management conditions, and not to make precise calculations for an individual event.

As in the case of urban areas, suspended solids predictions are multiplied by empirical quality coefficients to give the concentration of each pollutant of interest, evaluated at the watershed outflow point. This provides a common basis for relating urban and rural areas contained in a single watershed.

In an operational sense, SWMM is most often used to simulate stormwater runoff events that occur over a period of a few hours to a few days, with time steps and rainfall inputs at intervals measured in minutes. In general, the model is most suitable for medium-sized drainage basins (<25 mi^2) although it will operate quite well on smaller areas and may, under certain conditions, be applied to larger areas.

Modifications to Original Model

In the course of the ABAG project, a number of modifications were made in the original SWMM model. Most were straightforward modifications that tailored the model's

input and output to the needs of local users. Typical of such changes were a reformatting and condensation of the program's output and calculation and printing of the total mass of runoff for each water quality constituent.

In addition, several more significant changes were made as follows:

- All the program elements not necessary for simulation of the surface drainage system were eliminated.

- An option was added to the program to allow rural erosion to influence the quality of surface runoff. Previously, rural erosion (suspended solids) had been routed separately from urban erosion.

- An option was added to the program to allow the user to specify the unit quality constituent factors for both urban and rural dust and dirt. Prior to this, all values had been set from internally specified values which were taken from national surveys.

- An option was added to the program which will automatically determine the set of model coefficients which minimizes the differences between the model's predictions and field observations [3.5, 3.6]. This option, referred to as the Automatic Calibration Option, enhances the model's utility by facilitating both model calibration and verification, as explained below.

Operational Options

In its modified form, the SWMM model can be used in any of three modes of operation. A brief summary of each option and its functional characteristics is provided below.

Option A - Deterministic Simulation. Under the first option, SWMM is simply run as a deterministic design model. The user specifies the rainfall pattern and all the empirical coefficients and the model produces flow and quality time histories throughout the drainage basin. This type of operation is most suitable for evaluation of planning and design alternatives within a basin. In practice, a series of runs are usually made which reflect expected changes in such things as land use, the type and intensity of agricultural activity, or potential control

measures within an urban area. Deterministic simulation can also be used to estimate the relative importance of urban and rural contributions to the surface runoff problem. This may be the only type of simulation practical in the absence of flow and/or quality measurements in the basin.

Option B - Coefficient Calibration. If sufficient field data are available, the SWMM model may be run to evaluate numerically preselected sets of model coefficients in order to minimize the differences between model predictions and field observations. This process is called *model calibration* and is carried out as follows. First, the drainage basin is set up for simulation in exactly the same fashion as for a deterministic simulation with nominal values utilized for the model's coefficients. Next, the user selects the set of model coefficients for which he would like the best constrained estimates to be automatically determined. He specifies this information for input to the model together with a set of measurements against which the predictions of the model can be compared.

The model will then determine the unique set of coefficients which minimizes the differences between its simulated values and the field observations. The final set of coefficients generated by the model can be used in subsequent deterministic simulations under the assumption that they provide the best available estimate for making future calculations. When new data become available, the coefficients can be updated by a rerun of the model.

An example of model calibration is depicted in Figure 3-5 for runoff from the Glen Echo watershed. The calibration procedure was operated for four iterations, starting with the best available set of uncalibrated model coefficients. It is clear by inspection of successive results that sets of coefficients determined by the fourth iteration reduced the difference between model predictions and field observations which existed at the beginning of the procedure. It appears that the final set of coefficients could be used with confidence to provide a reasonable estimate of runoff in this particular basin.

As a final note, it is suggested that coefficient calibration be carried out for a number of discrete storm events if sufficient data are available. If several independent estimates can be made for the model's coefficients, the mean estimate should provide the most reasonable approximation for the range of conditions evaluated.

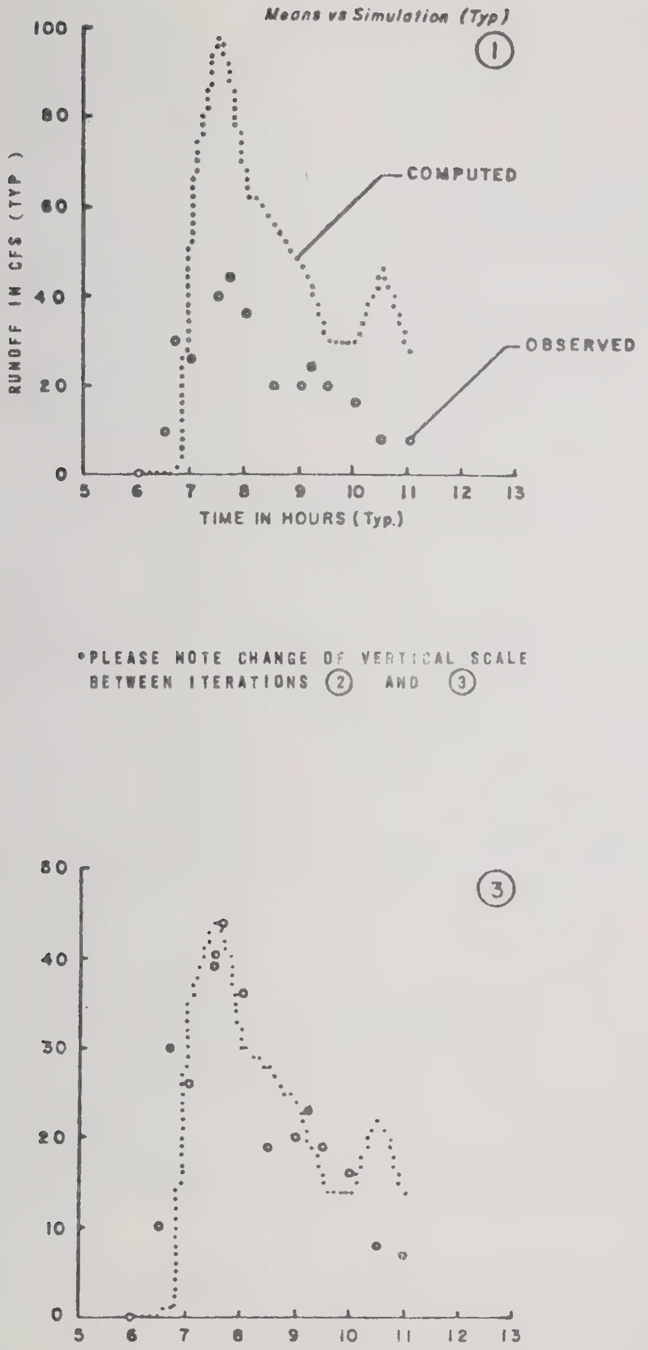


FIGURE 3-5. ILLUSTRATIVE EXAMPLE OF MODEL CALIBRATION FROM THE GLEN ECHO (OAKLAND) WATERSHED

Option C - Model Verification. The third mode of SWMM operation is used to evaluate the degree to which model calibration has actually identified the most desirable set of model coefficients. Use of this option requires a set of field observations independent of those used for model calibration. The verification procedure is simply to operate the model as if a calibration run were to be made, except the computer program is instructed to use the coefficients found in calibration and not to determine a new set of values. The output from the verification will be a quantification of the difference between model and field observations, in both graphical and tabular form, from which the user can judge the adequacy of the model's calibration.

Model Execution

Regardless of the mode of operation, implementation and use of the SWMM model follows a regular pattern, requiring a specific body of information. The most important aspects of the implementation procedure and usage of the SWMM model are summarized below.

Model Setup. Initial setup of the site specific model entails the following operations (see Figure 3-6).

- Preparation of a basin map which shows the watershed's boundaries, all natural and man-made channels, the location of all rain gages and gaging stations.
- Subdivision of the drainage basin into an appropriate number of subcatchments. Each subcatchment is a small drainage area with reasonably homogeneous land use and slope.
- Definition of a tree-shaped drainage system within the watershed which accurately reflects the surface flow paths.
- Estimation of the coefficients and parameters which describe the physical characteristics of the basin. If available, field observations of flow and/or quality behavior within the basin from known rainfall events should also be secured.

Data Preparation. The data requirements for SWMM are quite specific and are summarized in Table 3-1. For reference purposes, the exact card formats for use in the computer program are presented in Table C-1 in the Appendix to this report.

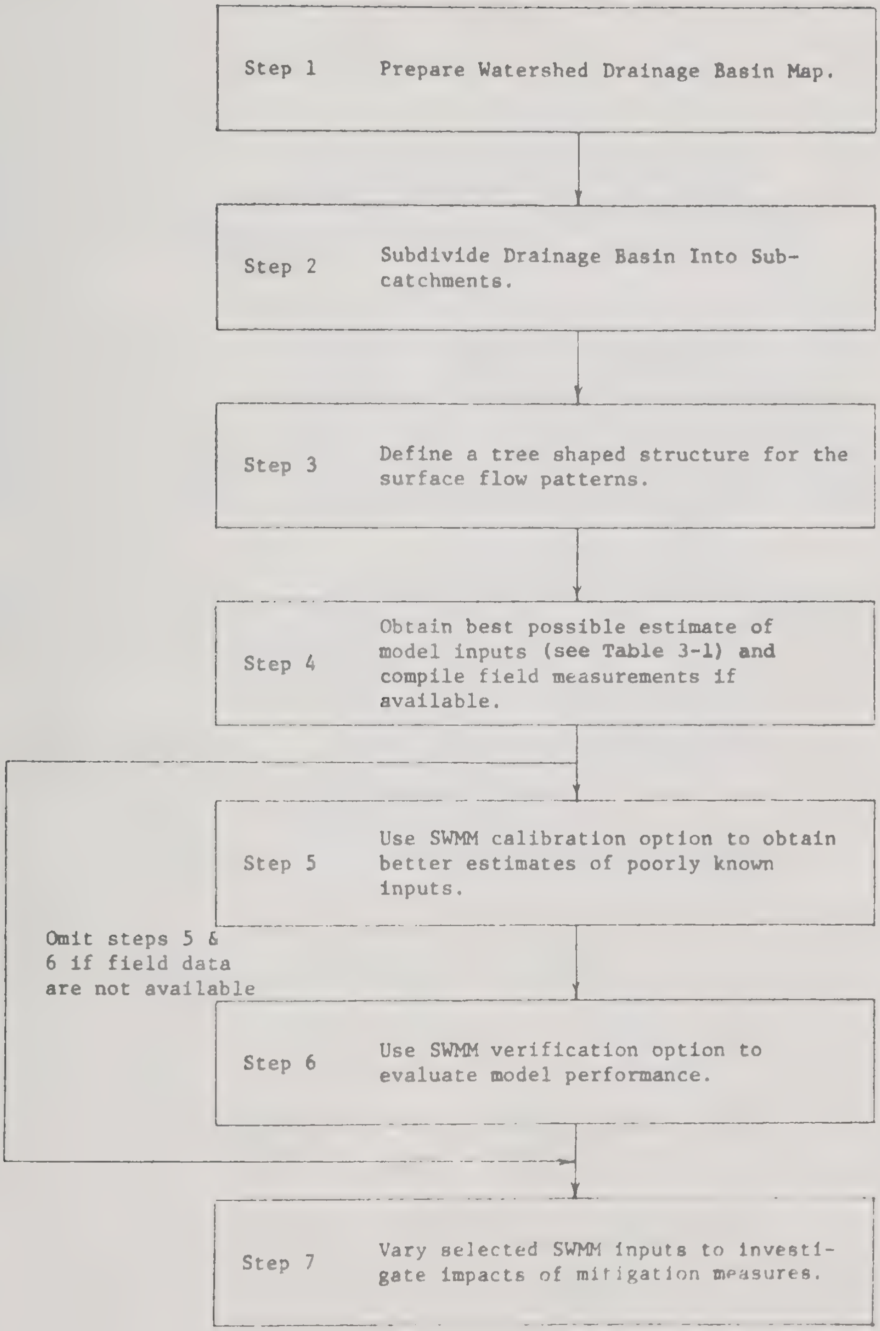


FIGURE 3-6. PROCEDURE FOR IMPLEMENTATION OF THE SWMM MODEL

Table 3-1. SUMMARY OF SWMM MODEL INPUTS AND THEIR RELATIONSHIP TO POTENTIAL MITIGATION MEASURES

Model input	Data source	Comments and related mitigation measures
Rainfall	Historical data obtained from Weather Bureau or local records at watershed rain gage locations. Design storm inputs constructed from engineering experience.	SWMM's response to both intensity and duration should be investigated for design storms.
Subcatchment characteristics		
Area	Subcatchments should be laid out hydrologically on basin maps and areas estimated or planimetered.	---
Average width	Estimated from subcatchment shape as shown on basin map. May be estimated in model calibration.	---
Average slope	Estimated from USGS slope or topographic maps or other maps showing elevations and land contours. May be estimated in model calibration.	Retention basins or other changes in the hydraulic system may change a basin's effective hydraulic slope.
Land use	LANDSAT, aerial photographs, planning reports, onsite observation.	Zoning controls and other land use controls will influence land use patterns.
Imperviousness	Aerial photographs. SCS soil classification maps, land use information and onsite inspection. May be estimated in model calibration.	Land use and building controls will influence imperviousness.
Roughness	Onsite observations, SCS maps, aerial photographs and any other detailed information on surface conditions. May be estimated in model calibration.	Land use, density of development and building controls will influence roughness.
Surface retention	Same source as imperviousness. Onsite inspection probably required for accurate estimates, especially in urban areas. May be estimated in model calibration.	Surface retention may be varied to investigate different types of land use and surface detention control measures.
Infiltration coefficients	May be obtained from the literature if soil type and land use information are available. Also may be estimated during calibration.	Infiltration may be varied to investigate different types of land use and soil surface control measures.
Channel/gutter number for drainage	Assigned on base map layout of watershed subcatchment network.	---
Channel characteristics		
Channel/gutter number for drainage	Assigned on base map layout of watershed subcatchment network.	---
Channel gutter geometric information	Obtained from public works drainage maps or city planning documents. In rural areas, obtained from USGS base maps and onsite observations.	---
Channel/gutter Manning coefficients	Deduced from pipe or gutter information on drainage maps. In rural areas, estimated from aerial photographs, SCS soil maps, or onsite inspection.	---
Pollutant loadings		
Street sweeping information	Historical records from Department of Public Works.	May be varied to simulate alternative street-sweeping practices.
Agricultural practices information	Obtained from Department of Agriculture literature, local farm advisory groups, county agencies, or onsite observation.	May be varied to simulate alternative erosion control measures.
Equivalent gutter lengths	Obtained from base map for urban areas. Must be estimated for rural areas.	May be varied to simulate alternative land use and building controls affecting population density.
Constituent percentages of dust and dirt	Obtained from previous studies. May be estimated in model calibration.	---

Estimation of Model Coefficients. The data requirements of Table 3-1 indicate the need for a large number of model coefficients and parameters, many of which may be poorly known. To define the necessary values, the user has two options. First, in a basin for which no field observations are available the user is generally required to use either the model's default options or to supply alternative values based on judgment or previous experience. Verification of the model in an ungaged basin will rely solely on a judgmental determination of the reasonableness and consistency of the model's output.

For a gaged basin, estimation of the model's coefficients and verification of the model's performance can be done in a much more quantified fashion. In such cases, SWMM's calibration option should be used to estimate unknown coefficients and to evaluate and verify the performance of the model. The use of the calibration option is strongly recommended wherever field data are available.

Reliability of Model Predictions. To date, no completely satisfactory way has been found to quantify the reliability of the SWMM model. In ungaged basins, flow predictions can be expected to deviate from fact by +100%, with quality concentrations displaying even more variability. As a general statement, the level of accuracy and detail that go into the model setup will be proportionately reflected in the model's results. Detail for detail's sake will not, however, improve the reliability of the simulation.

In the case where field data are available, one can make more definite statements concerning the model's reliability. If the model has been calibrated on several independent storms (say three or more), there is good reason to expect the accuracy of future simulations to be at least as good as that of the model verification. In the final analysis, whether or not this degree of accuracy is sufficient will depend on the judgment of the analyst and the needs of the particular study.

SWMM Usage in the Planning Process. The value of the SWMM model in the planning process is found in its ability to predict the impact of alternative management plans on the quantity and quality of surface runoff. Once the model has been implemented for a particular basin, it is relatively simple to modify the model's inputs to reflect such things as changes in land use patterns, the influence of intrabasin storage, interbasin transfers, or urban control measures. Comparison of the basin's flow and quality response to such alternatives can then be included as a major factor in developing and evaluating the final version of the environmental management program.

RECEIVING WATER SIMULATOR

The receiving water simulator used to represent the estuarine environment of San Francisco Bay and Delta is a successor of the Link-Node model developed by Water Resources Engineers, Inc., in the early 1960s and subsequently refined through repeated usage [3.2, 3.7, 3.8]. Modeling runs for the surface runoff management program were executed by ABAG staff and are described elsewhere [3.9, 3.10]. Only a brief descriptive summary follows based on abstractions from the referenced works.

Link-Node Model [3.9]

Mathematical abstraction of estuarine geometry is accomplished by subdividing the waterbody into discrete volume units or "nodes." Nodes are characterized by surface area, depth, volume, and side slopes. All water quality parameters that characterize the system are associated with these nodes. Pollutants entering each node are treated as instantaneously completely mixed throughout the nodal volume.

Nodes are interconnected by channels or "links." Links are defined by length, width, cross-sectional area, hydraulic radius (depth), and a friction factor. Water is constrained to flow from one node to another through the defined channels, advecting and "diffusing" water quality constituents between nodes. A link-node network may be employed to represent either a two-dimensional embayment, or a system of discrete estuarial channels, or combinations of channels and shallow bays.

The estuarial network employed to represent San Francisco Bay is shown in Figure 3-7. While such a network is comprised of "one-dimensional" channels, the technique has been successfully employed in modeling a wide variety of shallow estuarial systems, the most notable example being the Bay-Delta system in California, as shown.

It can be seen from the figure that the node and link system can easily be adapted to any prototype geometry with a widely varying degree of detail. Experience has shown that systems thus formed are capable of reproducing prototype hydrodynamic behavior with a high degree of reliability and provide an excellent base for quality characterization.

In application of the model, it is customary to impose a representative set of hydrologic and tidal conditions at the boundaries and run the model over several cycles, say two or

FIGURE 3-7. NETWORK FOR SAN FRANCISCO BAY SIMULATOR

three diurnal periods, until hydrodynamic equilibrium is reached. Computation intervals are separated by only a few minutes in prototype scale.

The resulting equilibrium data for a complete tidal cycle--velocities, discharges, inflows, tidal stages, water volumes, depths, and surface areas--are written on a tape at intervals suitable for the dynamic quality simulation. Data are stored as averages over intervals of 1 to 4 hours, depending on the detail required. In addition, the average hydraulic conditions over a tidal cycle are computed to be used for steady state water quality models or tidal average water quality models.

Output Analysis

Beyond calibration and verification, the only receiving water simulation outputs of interest are the long-term and transient water quality impacts of the generated surface runoff and background loadings. Three dimensional graphics are used very effectively for this purpose, as will be discussed under Section 5, the presentation of results.

The development of the surface runoff and background loadings, a necessary first step, is discussed in Section 4.

Section 4

MODEL APPLICATION

Model application begins with the subdivision of the study area into areas of ultimate interest (major watersheds) and areas of special interest (demonstration watersheds) and the assignment of appropriate rainfall records to each subdivision. Quantity and quality data are estimated from available source data and subsequently are calibrated to conditions of apparent "best fit." Finally, projections and mitigation measures are applied and impacts observed and interpreted.

In this section, the model application techniques and parameter selections used in the ABAG Surface Runoff Management element are summarized. The results are analyzed in Section 5.

SITE, DEMOGRAPHIC, AND HYDROLOGIC DATA

Area Subdivision Into Modeling Elements

The nine county study area was subdivided into 69 major watersheds of which 8 drain directly to the Pacific Ocean; 59 drain to San Francisco Bay; and 2 drain via the Pajaro River to Monterey Bay. The average watershed area is 44,000 acres (69 mi^2) and the range is from 869 acres (1.4 mi^2) to 157,991 acres (247 mi^2).

The major watersheds and subareas as classified for MAC are shown in Figures 4-1 through 4-4 and summarized in Table 4-1. The total study area breakdown by land use and subarea classification is shown in Table 4-2. Only in Napa County was a distinction made between agricultural use and open space; thus, agricultural land use in the overall study area is generally understated.

It is noteworthy that 87% of the total study area is classified as open or agricultural use, including 51% of the land identified as existing urban, Type C. The remaining 13% is made up of residential, 9%; commercial, 2%; and industrial, 2%. This great imbalance in land use makeup, as will be discussed in Section 5, is a major deterrent to pronounced and widespread water quality improvement as a direct result of surface runoff controls.

FIGURE 4-1. MAC WATERSHEDS - NW

FIGURE 4-2. MAC WATERSHEDS - NE

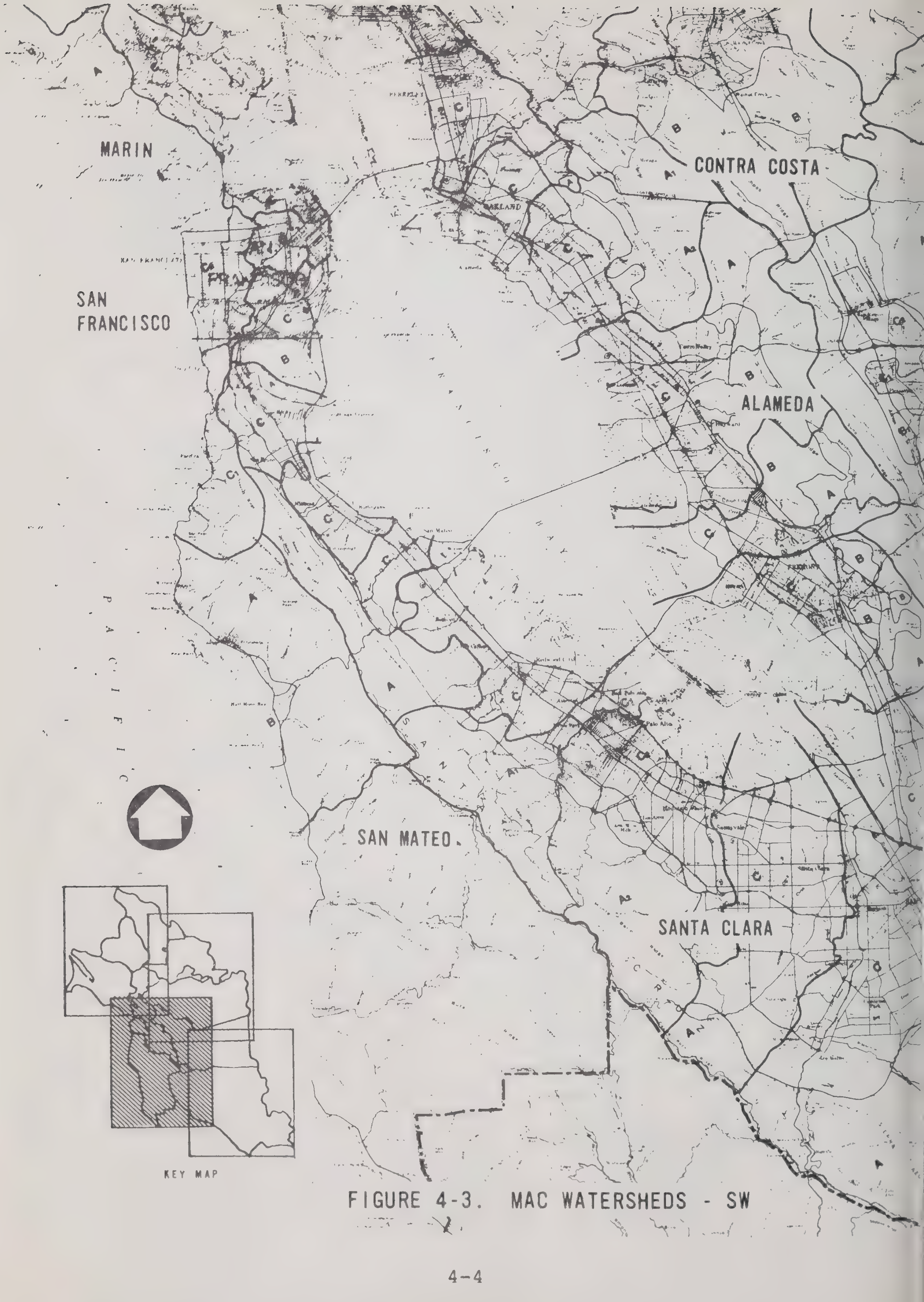


FIGURE 4-3. MAC WATERSHEDS - SW

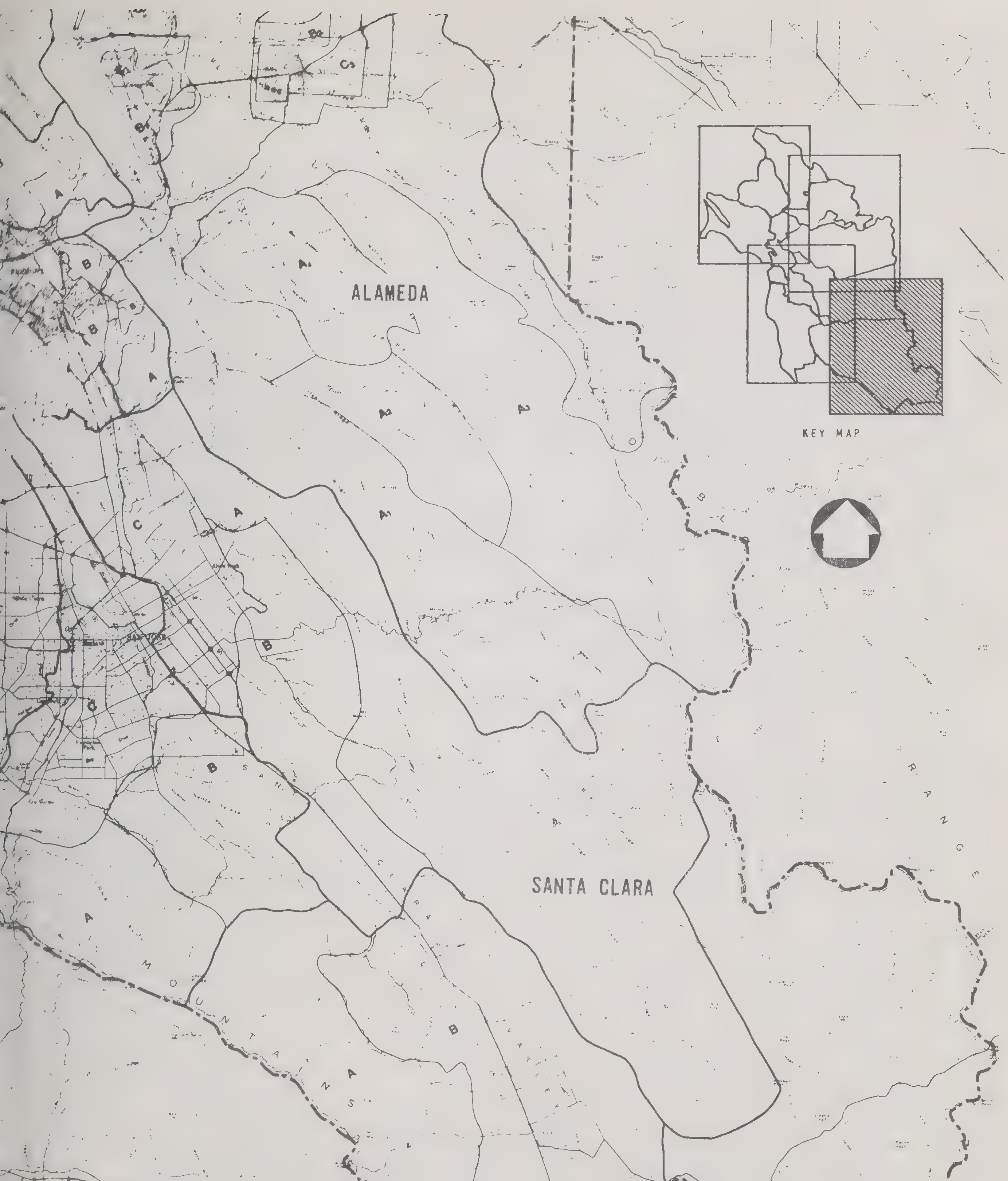


FIGURE 4-4. MAC WATERSHEDS - SE

Table 4-1. MAJOR WATERSHED AND SUBAREA BASIC DATA FOR MAC ANALYSES

County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Rainfall: Gage ID[c]	Rainfall: Transfer factor	Rainfall: Avg annual (1969-1970, 1970-1971 water year), in.	Discharge location: Bay model node, where applicable[d]
Alameda (Bayside)							
Berkeley	C	14,523	SEP	5	0.85	18.69	BN-008
Lake Merritt	C	20,808	SEP	5	0.85	18.69	BN-015
San Leandro	A	11,939	UNS	5	1.20	26.38	BN-019 via San Leandro and Lake Chabot Reservoir
San Leandro	C	20,029	SEP	5	0.70	15.39	BN-019
Hayward	A	15,381	UNS	5	1.05	23.08	BN-038
Hayward	B	6,708	SEP	5	0.90	19.79	BN-038
Hayward	C	43,304	SEP	5	0.80	17.59	BN-038
Lower Alameda Cr.	A	9,452	UNS	5	0.85	18.69	BN-040
Lower Alameda Cr.	B	6,558	SEP	5	0.90	19.79	BN-040
Lower Alameda Cr.	C	14,098	SEP	5	0.65	14.29	BN-040
Fremont	A	4,244	UNS	5	0.85	18.69	BN-046
Fremont	B	7,043	SEP	5	0.75	16.49	BN-046
Fremont	C	35,631	SEP	5	0.60	13.19	BN-046
Alameda (Upper Alameda Creek)							
Calaveras (U.A.Cr.)	A1	64,124	UNS	6	0.95	22.31	BN-040 via Calaveras Reservoir
Upper Alameda Cr.	A2	22,590	UNS	6	1.05	24.66	BN-040
Arroyo Valle (U.A.Cr.)	A3	86,627	UNS	6	0.85	19.96	BN-040 via Arroyo del Valle Reservoir
San Antonio (U.A.Cr.)	A4	27,973	UNS	6	0.95	22.31	BN-040 via San Antonio Reservoir
DeLa Laguna	A5	157,991	UNS	6	0.60	14.09	BN-040
Pleasanton	B	10,864	SEP	6	0.85	19.96	BN-040
Livermore	B	9,355	SEP	6	0.60	14.09	BN-040
Las Positas	B	5,643	SEP	6	0.60	14.09	BN-040
Pleasanton	C1	3,345	SEP	6	0.75	17.61	BN-040
Dublin	C2	6,534	SEP	6	0.80	18.79	BN-040
Livermore	C3	8,435	SEP	6	0.60	14.09	BN-040

Table 4-1. (Continued)

County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Rainfall: Gage ID[c]	Rainfall: Transfer factor	Rainfall: Avg annual (1969-1970, 1970-1971 water year), in.	Discharge location: Bay model node, where applicable[d]
Contra Costa							
Marsh Creek	A	44,866	UNS	4	1.00	18.73	BN-215
Marsh Creek	B	25,981	UNS	4	0.70	13.11	BN-215
Kellog	A	41,059	UNS	4	0.80	14.99	BN-228
Walnut Creek	B	57,163	SEP	4	1.00	18.73	BN-109
Walnut Creek	C	33,954	SEP	4	1.00	18.73	BN-109
Diablo	B	20,131	SEP	4	1.00	18.73	BN-110
Diablo	C	6,858	SEP	4	1.00	18.73	BN-110
Alhambra	A	7,129	UNS	4	1.30	24.36	BN-101
Alhambra	B	1,628	SEP	4	1.10	20.61	BN-101
Alhambra	C	6,803	SEP	4	1.00	18.73	BN-101
San Pablo	A	22,244	SEP	4	1.10	20.61	BN-057 via San Pablo and Briones Reservoir
San Pablo	B	8,226	SEP	4	1.30	24.36	BN-057
San Pablo	C	8,468	SEP	4	1.00	18.73	BN-057
Pinole	A	13,986	SEP	4	1.30	24.36	BN-074
Pinole	B	10,371	SEP	4	1.00	18.73	BN-074
Antioch	A	6,291	UNS	4	0.80	14.99	BN-115
Antioch	B	4,947	SEP	4	0.70	13.11	BN-115
Antioch	C	7,959	SEP	4	0.70	13.11	BN-115
West Pittsburgh	A	7,721	UNS	4	0.70	13.11	BN-111
West Pittsburgh	C	16,205	SEP	4	0.90	16.86	BN-111
Upper San Leandro	A	16,735	SEP	4	1.60	29.90	BN-019 via San Leandro and Lake Chabot Reservoir
Richmond	C	12,339	SEP	4	1.20	22.48	BN-010
Delta Lowland	B	56,124	UNS	4	0.60	11.24	Delta
Marin							
Richardson Bay	C	14,321	SEP	1	1.30	38.41	BN-013
Corte Madera Cr.	C	17,932	SEP	1	1.60	47.27	BN-055
San Rafael	C	21,224	SEP	1	1.60	47.27	BN-058
Novato	C	29,318	SEP	1	1.10	32.50	BN-060
San Antonio Cr.	A	11,238	UNS	1	0.90	26.59	BN-067

Table 4-1. (Continued)

County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Rainfall: Gage ID[c]	Rainfall: Transfer factor	Rainfall: Avg annual (1969-1970, 1970-1971 water year), in.	Discharge location: Bay model node where applicable[d]
Marin (cont'd)							
Lagunitas Creek	A1	23,344	UNS	1	1.60	47.27	Ocean via Tomales Bay
Lagunitas Creek	A2-A4	35,248	UNS	1	1.50	44.32	Ocean via Tomales Bay via Nicasio Reservoir and Kent Lake
Lagunitas Creek	A3	6,568	UNS	1	1.60	47.27	Ocean via Tomales Bay
Tomales Bay	A1	9,791	UNS	1	0.90	26.59	Ocean via Tomales Bay
Tomales Bay	A2	12,983	UNS	1	1.10	32.50	Ocean via Tomales Bay
Tomales Bay	A3	45,315	UNS	1	1.10	32.50	Ocean via Tomales Bay
Point Reyes	A	44,222	UNS	1	1.20	35.45	Ocean
Bolinas-Stinson	A	23,481	UNS	1	1.20	35.45	Ocean
Bolinas-Stinson	C	927	SEP	1	1.50	44.32	Ocean
Napa							
Upper Napa River	A	53,340	UNS	2	1.10	40.38	BN-093
Upper Napa River	B	12,304	UNS	2	1.00	36.71	BN-093
Upper Napa River	C	2,000	SEP	2	1.00	36.71	BN-093
Middle Napa River	A	78,504	UNS	2	1.00	36.71	BN-093
Middle Napa River	B	34,889	UNS	2	0.90	33.04	BN-093
Middle Napa River	C	9,935	SEP	2	0.80	29.37	BN-093
American Canyon	A	31,123	UNS	2	0.70	25.70	BN-093
American Canyon	B	11,966	UNS	2	0.70	25.70	BN-093
American Canyon	C	869	SEP	2	0.70	25.70	BN-093
Wooden Valley	A	28,427	UNS	2	0.90	33.04	BN-123
Wooden Valley	B	2,843	UNS	2	0.90	33.04	BN-123
Santa Clara							
Palo Alto-Mtn.View	A	33,862	SEP	7	2.50	31.09	BN-050
Palo Alto-Mtn.View	C	33,034	SEP	7	1.00	12.43	BN-050
Santa Clara, et al.	A	2,022	SEP	7	2.40	29.84	BN-052
Santa Clara, et al.	C	46,393	SEP	7	1.00	12.43	BN-052
San Jose southwest	A	33,992	UNS	7	2.40	29.84	BN-053 via Lexington, Guadalupe, Almaden, and Calero reservoirs
San Jose southwest	B	29,474	SEP	7	1.50	18.65	BN-053
San Jose southwest	C	46,758	SEP	7	1.00	12.43	BN-053
Coyote-Silver	A	141,183	UNS	7	1.60	19.90	BN-054 via Coyote Reservoir

Table 4-1. (Continued)

County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Rainfall: Gage ID[c]	Rainfall: Transfer factor	Rainfall: Avg annual (1969-1970, 1970-1971 water year), in	Discharge location: Bay model node where applicable[d]
Santa Clara (cont'd)							
Coyote-Silver	B	45,727	SEP	7	1.20	14.92	BN-054
Coyote-Silver	C	39,269	SEP	7	1.10	13.68	BN-054
Llagas-Uvas	A	66,095	UNS	7	1.50	18.65	Ocean via Pajaro River via Llagas and Uvas reservoirs
Llagas-Uvas	B	73,032	SEP	7	1.50	18.65	Ocean via Pajaro River
Pacheco	A	106,924	UNS	7	1.20	14.92	Ocean via Pajaro River
San Francisco							
San Francisco S.E.	C	8,758	COM	9	1.00	19.79	BN-017
San Francisco N.Pt.	C	5,717	COM	9	1.00	19.79	BN-003
San Francisco N.Shr.	C	3,062	COM	9	1.00	19.79	BN-002
San Francisco R-S	C	10,991	COM	9	1.00	19.79	Ocean
San Mateo							
Pacifica	C	12,792	SEP	8	1.30	24.82	Ocean
Brisbane	B	4,431	SEP	8	1.10	21.00	BN-020
So.San Francisco	C	11,076	SEP	8	1.30	24.82	BN-021
Millbrae-Burlingame	C	10,564	SEP	8	1.40	26.73	BN-026
San Mateo Creek	A	22,419	UNS	8	1.80	34.36	BN-031 via Crystal Springs and San Andres Reservoir
San Mateo Creek	C	7,717	SEP	8	1.30	24.82	BN-031
Belmont-Atherton	C	30,742	SEP	8	1.10	21.00	BN-035
San Francisquito	A	22,320	UNS	8	1.40	26.73	BN-044
San Francisquito	C	7,091	SEP	8	1.00	19.09	BN-044
Pescadero Creek	A	112,978	UNS	8	1.60	30.54	Ocean
Half Moon Bay	A	37,637	UNS	8	1.80	34.36	Ocean
Half Moon Bay	B	3,192	SEP	8	1.10	21.00	Ocean
Solano							
Vallejo-Benicia	A	22,485	UNS	3	0.90	16.96	BN-089
Vallejo-Benicia	B	8,703	SEP	3	0.90	16.96	BN-089
Vallejo-Benicia	C	15,616	SEP	3	0.90	16.96	BN-089
Fairfield-Suisan	A	61,371	UNS	3	1.00	18.84	BN-123
Fairfield-Suisan	B	10,987	SEP	3	1.00	18.84	BN-123
Fairfield-Suisan	C	9,551	SEP	3	1.00	18.84	BN-123
Collinsville	A	83,877	UNS	3	0.85	16.01	BN-117
Collinsville	B	7,155	UNS	3	0.85	16.01	BN-117

Table 4-1. (Concluded)

County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Rainfall: Gage ID[c]	Rainfall: Transfer factor	Rainfall: Avg annual (1969-1970, 1970-1971 water year), in.	Discharge location: Bay model node where applicable[d]
Sonoma							
Glen Ellen	A	24,027	UNS	1	1.20	35.45	BN-085
Glen Ellen	B	12,898	UNS	1	1.20	35.45	BN-085
Glen Ellen	C	941	SEP	1	1.20	35.45	BN-085
Sonoma	A	14,613	UNS	1	1.10	32.50	BN-085
Sonoma	B	18,870	UNS	1	1.10	32.50	BN-085
Sonoma	C	1,883	SEP	1	1.10	32.50	BN-085
Bayside	A	19,364	UNS	1	0.70	20.68	BN-085
Bayside	B	17,131	UNS	1	0.70	20.68	BN-085
Penngrove	A	2,694	UNS	1	0.90	26.59	BN-069
Penngrove	B	16,231	UNS	1	0.90	26.59	BN-069
Penngrove	C	1,044	SEP	1	0.90	26.59	BN-069
Petaluma Valley	A	4,017	UNS	1	1.00	29.54	BN-069
Petaluma Valley	B	12,077	UNS	1	1.00	29.54	BN-069
Petaluma Valley	C	2,817	SEP	1	1.00	29.54	BN-069
Petaluma River	A	9,881	UNS	1	0.90	26.59	BN-069
Petaluma River	B	20,178	UNS	1	0.90	26.59	BN-069
San Antonio Marin	A	8,092	UNS	1	0.90	26.59	BN-067
San Antonio Marin	B	6,518	UNS	1	0.90	26.59	BN-067

a. A - Natural or protected
B - Potentially developable
C - Existing urban

b. SEP - Separate storm and sanitary sewers
UNS - Predominately open drainage and culverts
COM - Combined storm and sanitary sewers

c. Refer to Figure 4-5.

d. Refer to Figure 3-7.

Table 4-2. SUMMARY OF STUDY AREA BREAKDOWN BY LAND USE - 1975

County	Total subareas	Land use, acres						
		Residential	Residential-multifamily	Commercial	Industrial	Open	Agricultural	Total
Alameda (Bayside)	13	47,905	0	12,973	13,493	135,347	0	209,718
Alameda (upper Alameda Creek)	11	8,010	0	2,039	620	392,812	0	403,481
Contra Costa	23	38,563	1,910	9,948	8,907	377,860	0	437,188
Marin	14	23,144	2,675	2,574	667	271,852	0	300,912
Napa	11	10,907	0	749	787	177,440	76,317	266,200
San Francisco	4	12,542	0	7,199	3,921	4,866	0	28,528
San Mateo	12	44,068	3,315	5,032	5,494	225,050	0	282,959
Santa Clara	13	68,145	0	18,853	15,923	594,844	0	697,765
Solano	8	8,362	0	2,966	1,385	207,032	0	219,745
Sonoma	18	5,160	231	1,619	743	185,523	0	193,276
Subarea subtotals								
Classification A	50	20,960	323	2,755	910	175,041	23,700	1,798,789
Classification B	33	31,305	658	5,446	3,819	485,503	52,617	579,348
Classification C	44	214,541	7,150	55,751	47,211	336,982	0	661,635
Study area total	127	266,806	8,131	63,952	51,940	2,572,626	76,317	3,039,772

The land use data, existing and projected, were developed by ABAG through its 440-zone planning model. The zones, 440 in number, are based on aggregations of census tracts. These zones are the basic analysis units used by ABAG and the Metropolitan Transportation Commission for regional projections of population, employment, and land use. The latest of these projections, called Series 3 with 1975 as a base year, were used in the MAC analyses. Transfer from 440 zone limits to MAC watersheds was facilitated by correspondence tables, also furnished by ABAG, and ultimately developed into automatic programming [4.1].

Population

Population data, existing and projected, were developed through the same mechanism as land use. A provisional set of projections developed by ABAG [4.2] showing high and low growth estimates is shown in Table 4-3. Total regional estimates were made to the year 2000, but at the time published, county breakdowns were through 1990 only.

Table 4-3. POPULATION PROJECTIONS [4.2]
(All data in 1000s)

County	1975	1990 High	1990 Low
Alameda	1,089.9	1,180.3	1,163.4
Contra Costa	582.8	774.3	690.5
Marin	216.1	251.9	237.2
Napa	90.0	109.0	90.3
San Francisco	672.6	641.9	645.1
San Mateo	576.4	606.1	597.0
Santa Clara	1,169.7	1,367.0	1,352.0
Solano	186.3	345.6	227.5
Sonoma	245.4	345.9	280.6
Region total	4,829.2	5,621.9	5,283.7

Santa Clara and Contra Costa counties show the largest growth potential (in terms of total population, not rate); whereas Marin, Napa, San Francisco, and San Mateo counties show relatively small changes.

Rainfall Network

To account for rainfall variability over the study area, daily historical rainfall records were collected from nine primary U.S. Weather Bureau rain gages distributed as shown in Figure 4-5. Source of the rainfall tapes was the National Climatic Center, NOAA Environmental Data Service, Federal Building, Asheville, North Carolina 28801.

Metcalf & Eddy adapted the records for direct MAC input, typically six card images per year, and logged the modified data in the ABAG user support library under the appropriate code identifiers listed in the appendix. The data generally span the period 1948-1975. From the complete set, two water years, 1969-1970 and 1970-1971, were selected as representative of "average" conditions and used in the workshop demonstration analyses.

Demonstration Watersheds

To augment the regional, rather coarse, analysis by MAC watersheds and to concentrate most effectively a very small monitoring budget within a limited time frame, several "demonstration watersheds" were selected, each representing a particular type of watershed found throughout the region. These demonstration watersheds were subsequently set up for runs using the site specific model.

In the San Francisco Bay region, most watersheds can be grouped into one of the following categories:

- Small urban watersheds--highly developed, high runoff coefficients, sewered
- Medium-size, mixed land use watersheds--usually developed downstream and undeveloped upstream, runoff coefficients dependent on antecedent soil moisture conditions
- Large undeveloped watersheds--rural watersheds with some development in valleys, relatively low runoff coefficients, significant sedimentation

A number of candidate watersheds in each category were identified early in the program. After consideration of data availability, potential water quality problems, suitability for monitoring and site specific modeling, and the degree of local interest in each candidate watershed, a final set of 12 was selected. General information on these 12 demonstration watersheds is listed in Table 4-4. Their

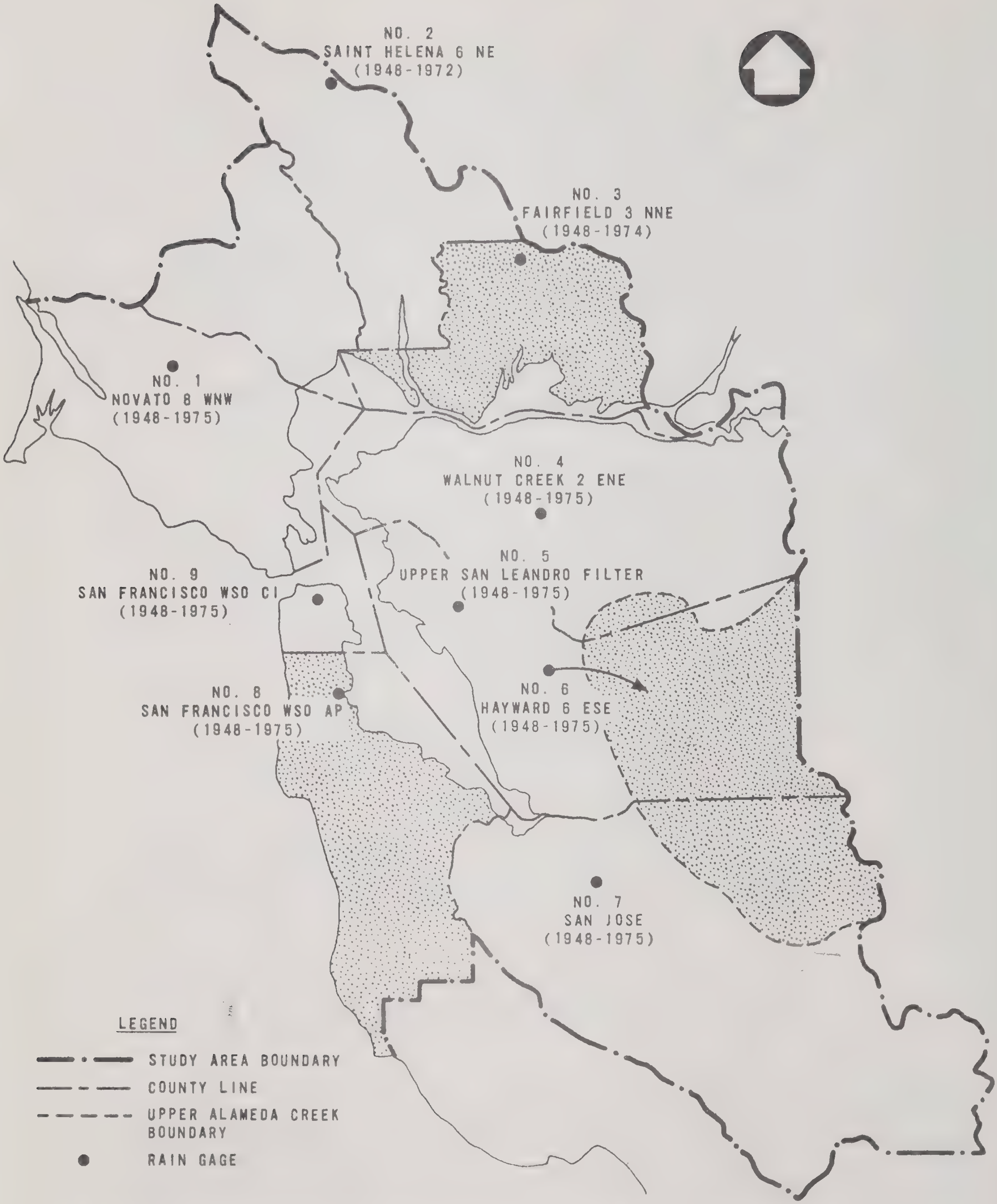


FIGURE 4-5. RAIN GAGE LOCATIONS AND APPLICATION AREAS

Table 4-4. GENERAL INFORMATION ON DEMONSTRATION WATERSHEDS SELECTED FOR SITE-SPECIFIC ANALYSIS

Watershed	County	Size, mi^2	Topography	Land use and cover	Potential surface runoff problems	Relevant mitigation measures which could be evaluated with SWMM
Small urban watershed						
Glen Echo Creek	Alameda	2.0	Slopes vary from small (0.01) downstream to large (0.30) upstream.	Mostly high density residential except along commercial arteries. Watershed includes a golf course and cemetary.	Solids, grease, etc. from streets and possible infiltration of storm flows.	Street-sweeping alternatives
Richmond	Contra Costa	2.5	Relatively flat (0.01 slopes) except in extreme upper reaches.	Heavily developed warehouse and commercial area in downstream portion. Otherwise high density residential.	Solids, grease, and industrial pollutants from warehouse and commercial areas.	Street-sweeping alternatives.
Napa York St.	Napa	0.2	Relatively flat (0101 slopes).	Medium density residential.	No significant problems identified.	---
Medium-size mixed land use watersheds						
Castro Valley Creek	Alameda	5.5	Slopes vary from small (0.01) downstream to large (0.30) in hilly upstream areas.	Includes central commercial area of Castro Valley and surrounding medium density housing.	Solids, grease, etc. from streets. Some commerical pollutnats.	Street-sweeping alternatives.
Sleepy Hollow Creek	Marin	2.2	Small valley in Marin hills. Mostly steep (0.20-0.30) except on valley floor.	Low density residential area.	No significant problems identified.	---
Calabazas Creek	Santa Clara	14.2	Slopes vary from small (0.01) in broad downstream area to large (0.40) in steep upstream hills.	Heavy residential and commercial downstream development is gradually spreading up the hills.	Sedimentation upstream. Solids and grease from developed downstream areas.	Erosion control and street-sweeping.
Colma Creek	San Mateo	10.5	Topography similar to Calabazas Creek watershed.	Heavily developed except on slopes of San Bruno mountain. Extreme downstream area is industrial.	Sedimentation, solids and grease from developed areas.	Street-sweeping.
Pine-Galinda	Contra Costa	28.3	Slopes vary from small (0.01) downstream to very steep (0.40) on Mt. Diablo.	Upstream area undeveloped park and grazing land. Suburban development in lower portions, including commercial strips with higher densities.	Sedimentation, nutrients from grazing, solids and grease from developed areas.	Erosion control and street-sweeping.
Large undeveloped watersheds						
Halleck Creek	Marin	8.8	Steep watershed in central Marin hills.	Completely undeveloped. Some grazing land with forested strips along Halleck and tributary creeks.	Some natural sedimentation.	---
Napa Creek	Napa	15.4	Steep watershed in western hills of Napa Valley.	Light development along creek. Heavily forested upstream areas. Some grazing.	Sedimentation.	Erosion control.
Sonoma Creek	Sonoma	58.2	Watershed covers most of upper Sonoma Valley. Very steep in hillsides, flatter open areas downstream.	Small towns and light residential development on valley floor. Some agriculture and grazing on hills.	Sedimentation.	Erosion control.
Green Valley Creek	Solano	21.6	Topography similar to Sonoma Creek watershed.	Land use and cover similar to Napa Creek watershed.	Sedimentation	Erosion control.

locations are noted in Figure 4-6. More detailed hydrologic and model-related information is provided in Table 4-5. A quick review of the summary tables shows that the demonstration watersheds differ considerably in size, demographic characteristics, and hydrology. As a group, they provide a reasonably representative cross-section of surface runoff conditions in the San Francisco Bay area.

The initial steps in site specific modeling, as discussed in the previous section, require the definition of the drainage network and hydrologic subareas (often called subcatchments) of the watershed. Subcatchments and drainage facilities for the 12 San Francisco Bay demonstration watersheds were laid out on topographic maps by county personnel and then reviewed by RMA to verify that the resulting hydrologic descriptions satisfied the model's input requirements. Four examples of the watershed maps produced by this joint effort are shown in Figures 4-7 through 4-10. Each map shows the subcatchment boundaries, pipes or stream channels, and flow gage locations used to characterize the watershed for simulation purposes.

Once the watershed maps were prepared, the various model coefficients and inputs listed in Table 3-1 had to be specified. Some inputs, such as subcatchment area or channel length, were fairly easy to compute. Others, such as infiltration rates and Manning coefficients, were more difficult to estimate. In such areas, reasonable input values (developed from experience with similar studies conducted elsewhere) were assumed and later modified during the model calibration process. Detailed tables listing all SWMM inputs for the 12 demonstration watersheds are provided in Appendix C.

QUANTITY AND QUALITY DATA

The recently experienced drought in California must have convinced even the most imperceptive of observers that the volume of surface runoff is capable of varying markedly from year to year. Lest our memories become short, average runoff volumes as a percentage of "normal" are reproduced in Figure 4-11 for the 1975 (wet) and 1976 (dry) water years as reported in the official USGS records [4.3, 4.4]. Note for example, that Napa River flows varied from 135% of normal in the wet year to 7% of normal in the dry, a near 20-fold variation. The ABAG 208-studies and monitoring were carried out in the 1977 water year which was drier yet.

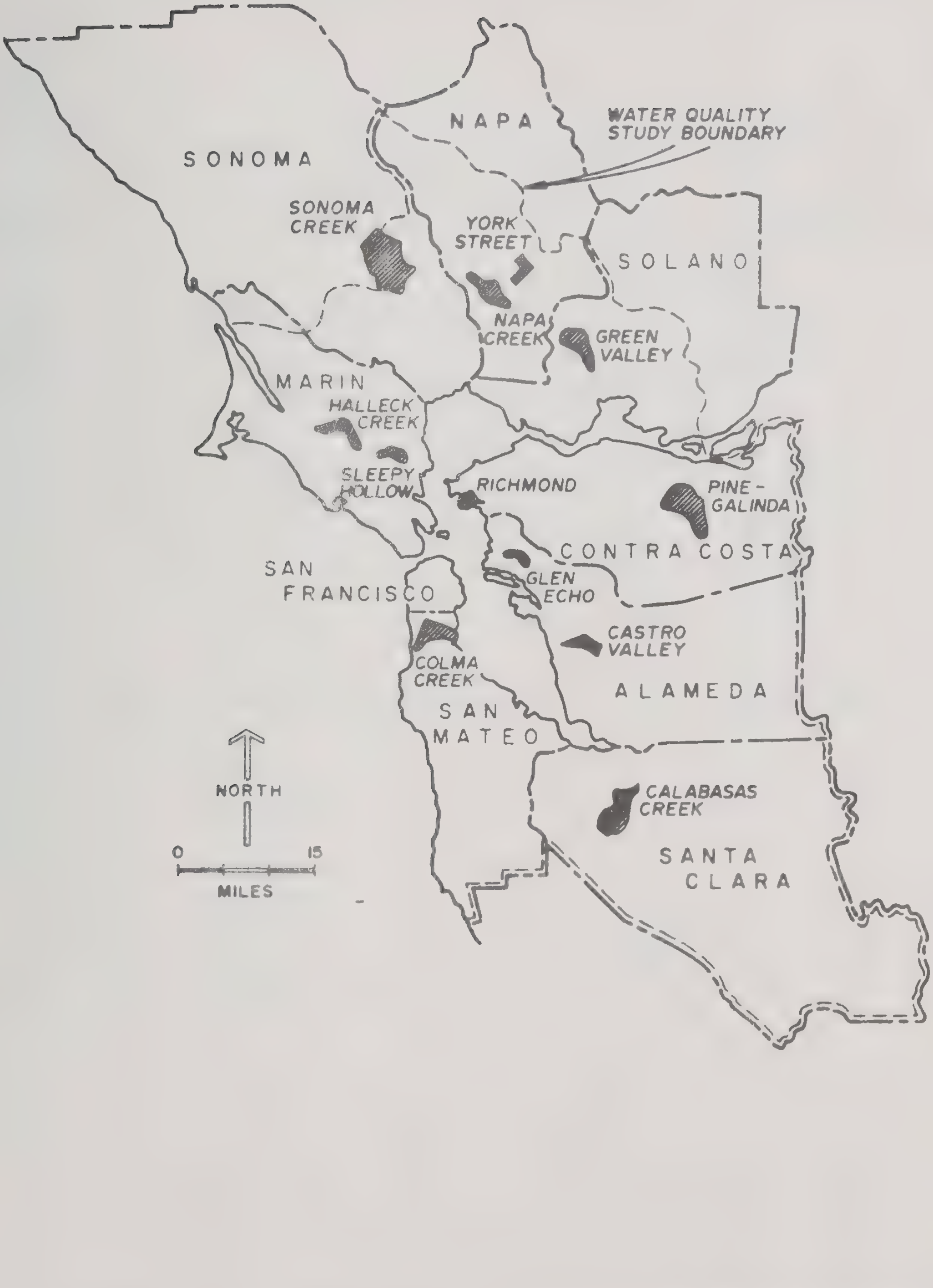


FIGURE 4-6. LOCATION OF DEMONSTRATION WATERSHEDS SELECTED FOR SITE-SPECIFIC ANALYSIS

Table 4-5. HYDROLOGIC INFORMATION ON DEMONSTRATION WATERSHEDS SELECTED FOR SITE SPECIFIC ANALYSIS

	Sub-catchments		Channels/pipes		Hydrologic properties			Rain gage information		
Watershed	No.	Avg area, acres	No.	Avg length, ft	Avg runoff coefficient, in./in.[a]	Mainstem length, mi	Representative time-of-concentration, hr	Location	Time interval, min	Discharge point
Small urban watersheds										
Glen Echo Creek	20	70	30	1,000	0.40-0.45	2.7	0.8	Piedmont fire station	15	Glen Echo Creek outlet beneath McArthur freeway
Richmond	13	120	16	1,500	0.30-0.40	2.5	1.0	Richmond city hall	15	Storm sewer 2,000 ft south of Hoffman Blvd near U.C. field station
Napa, York Street	19	10	29	400	0.25-0.30	1.0	0.4	Napa County Atlas Rd., Dutra gage	10	Intersection of York and A streets, Napa
Medium-size mixed land use watersheds										
Castro Valley Creek	41	80	53	1,200	0.20-0.30	2.3	0.5	Alameda County, Hayward corporation yard gage	15	USGS Castro Valley Creek gage at Hayward
Sleepy Hollow Creek	23	60	25	1,000	0.25-0.30	1.0	0.4	San Anselmo fire station	15	County gage near Butterfield Road crossing
Calabazas Creek	44	210	79	1,800	0.25-0.30	8.1	2.2	Three Santa Clara County gages as noted in Figure 4-8	15	County gage south of Monroe St.
Colma Creek	46	150	51	2,000	0.25-0.30	4.4	1.5	San Mateo County gages at San Bruno Mountain and Skyline College	15	USGS Colma Creek gage
Pine-Galinda	59	300	69	2,000	0.25-0.30	11.0	3.3	Contra Costa County gage WC2ENE	15	Pine Creek gage at Market St., Concord
Large undeveloped watersheds										
Halleck Creek	23	250	23	3,000	0.25-0.35	5.3	1.8	Marin Municipal Water District gage at Nicasio	15	Intersection of Halleck Creek with Nicasio Valley Rd.
Napa Creek	33	300	38	3,000	0.25-0.35	9.9	3.0	Napa County Yountville gage	10	USGS Napa Creek gage
Sonoma Creek	38	950	52	4,500	0.20-0.40	11.9	4.2	Glen Ellen forestry station	10	USGS Sonoma Creek gage at Agua Caliente Rd.
Green Valley Creek	43	320	50	3,000	0.20-0.40	8.0	3.0	Solano County Lake Madigan gage	60	USBR Green Valley Creek gage

a. The wide range of runoff coefficients given for the less developed watersheds reflects the importance of antecedent soil moisture conditions. The low values apply to dry soils and the high values to wet soils.

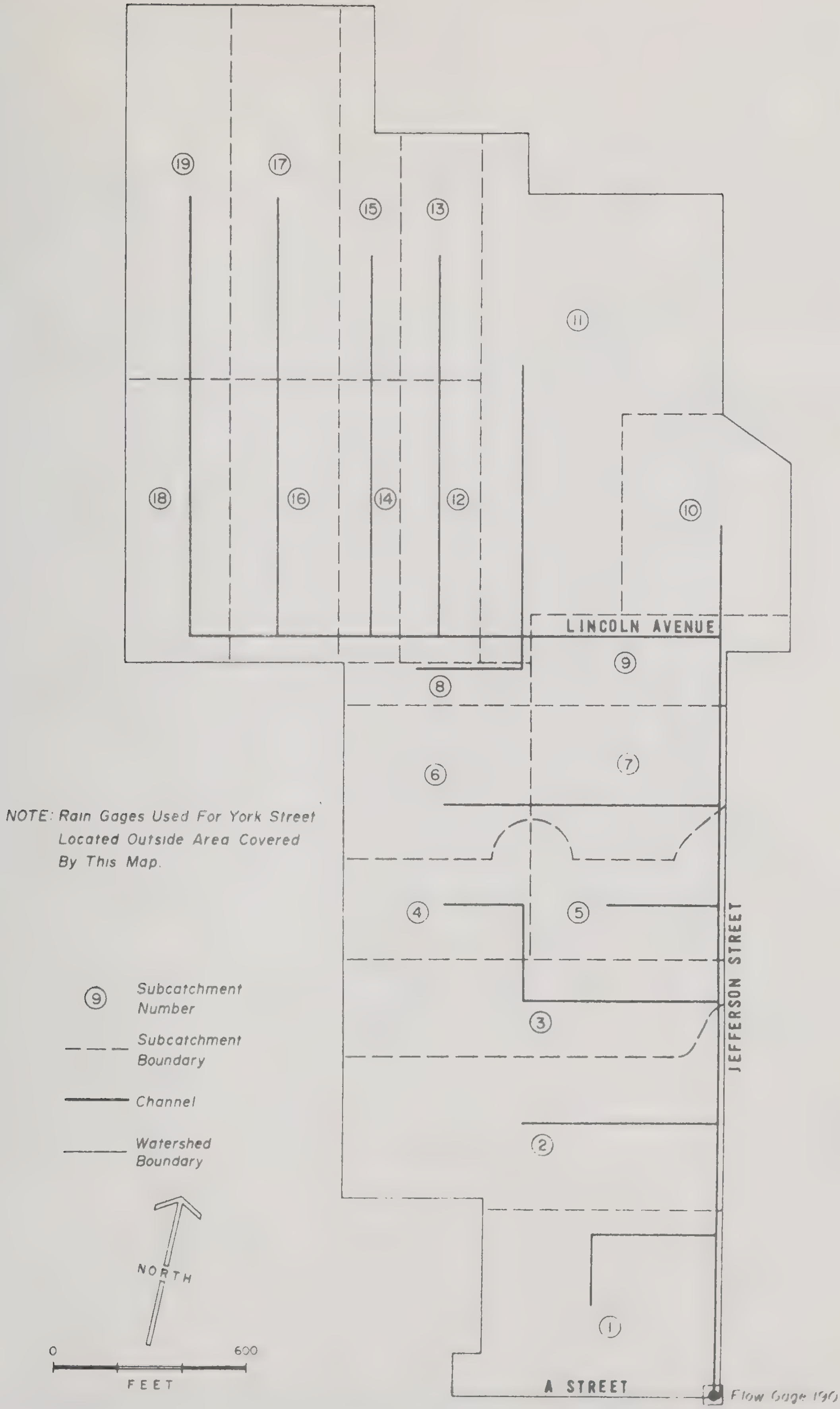


FIGURE 4-7. NAPA, YORK ST. DEMONSTRATION WATERSHED

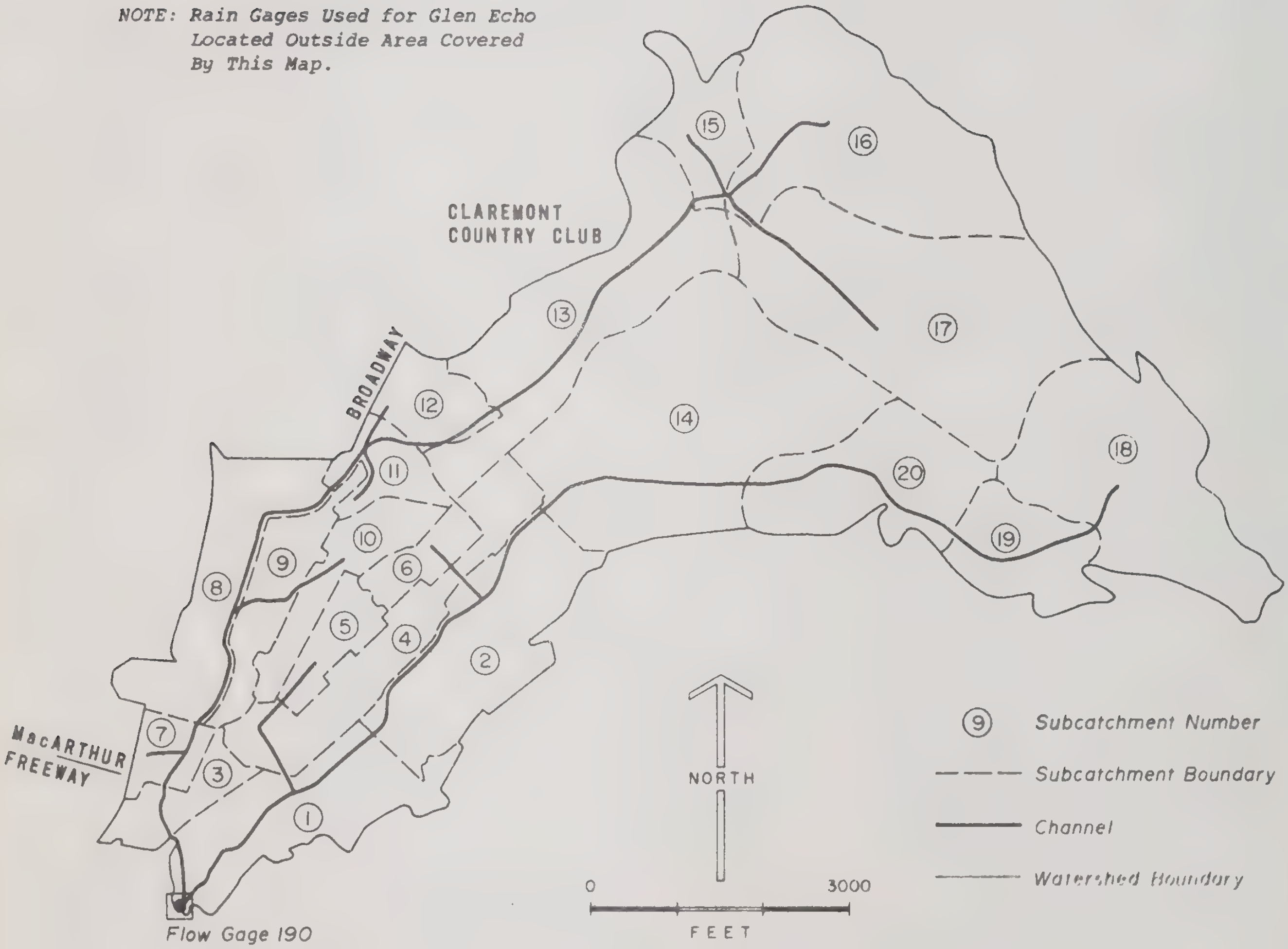


FIGURE 4-8. GLEN ECHO CREEK DEMONSTRATION WATERSHED

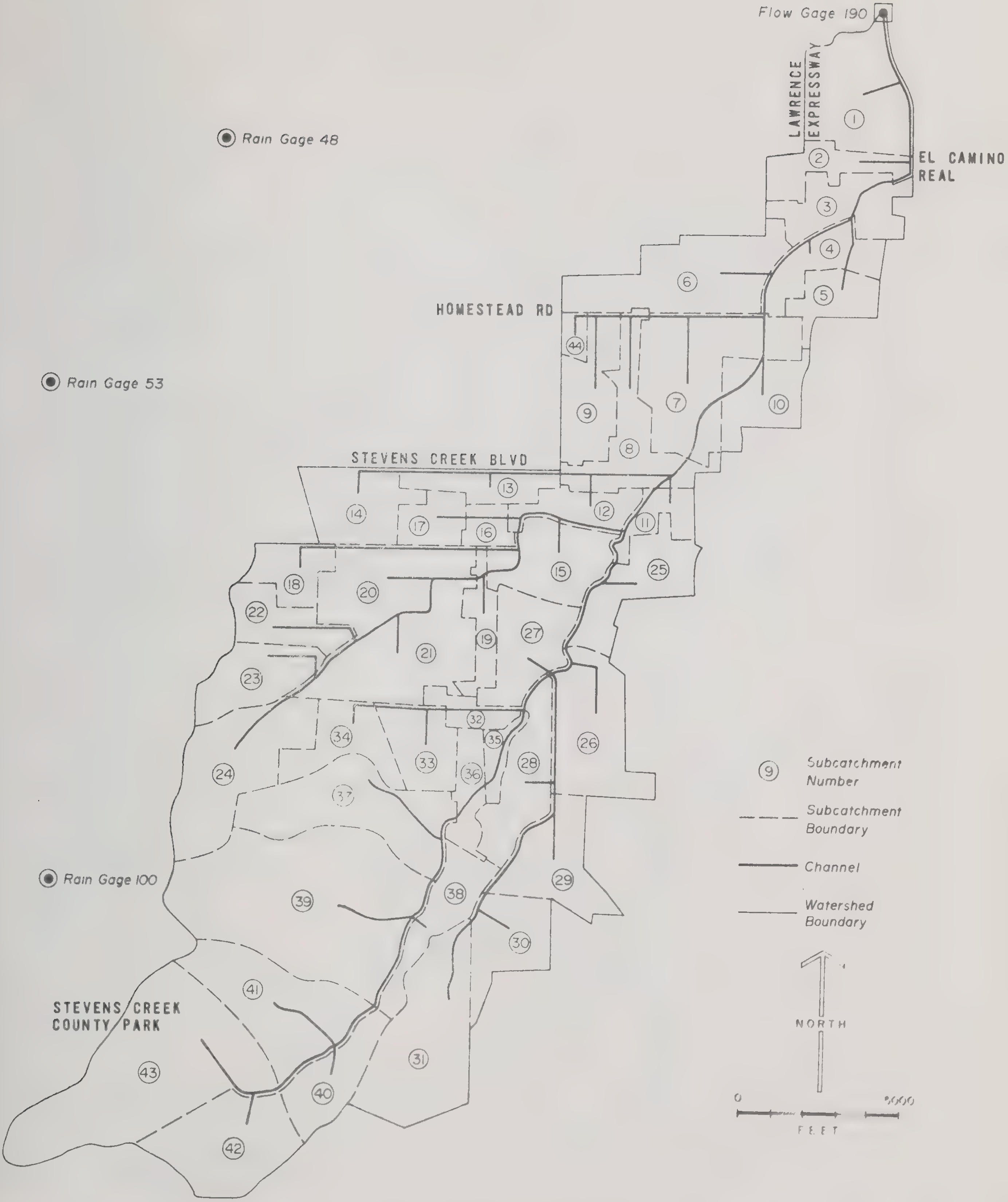


FIGURE 4-9. CALABAZAS CREEK DEMONSTRATION WATERSHED

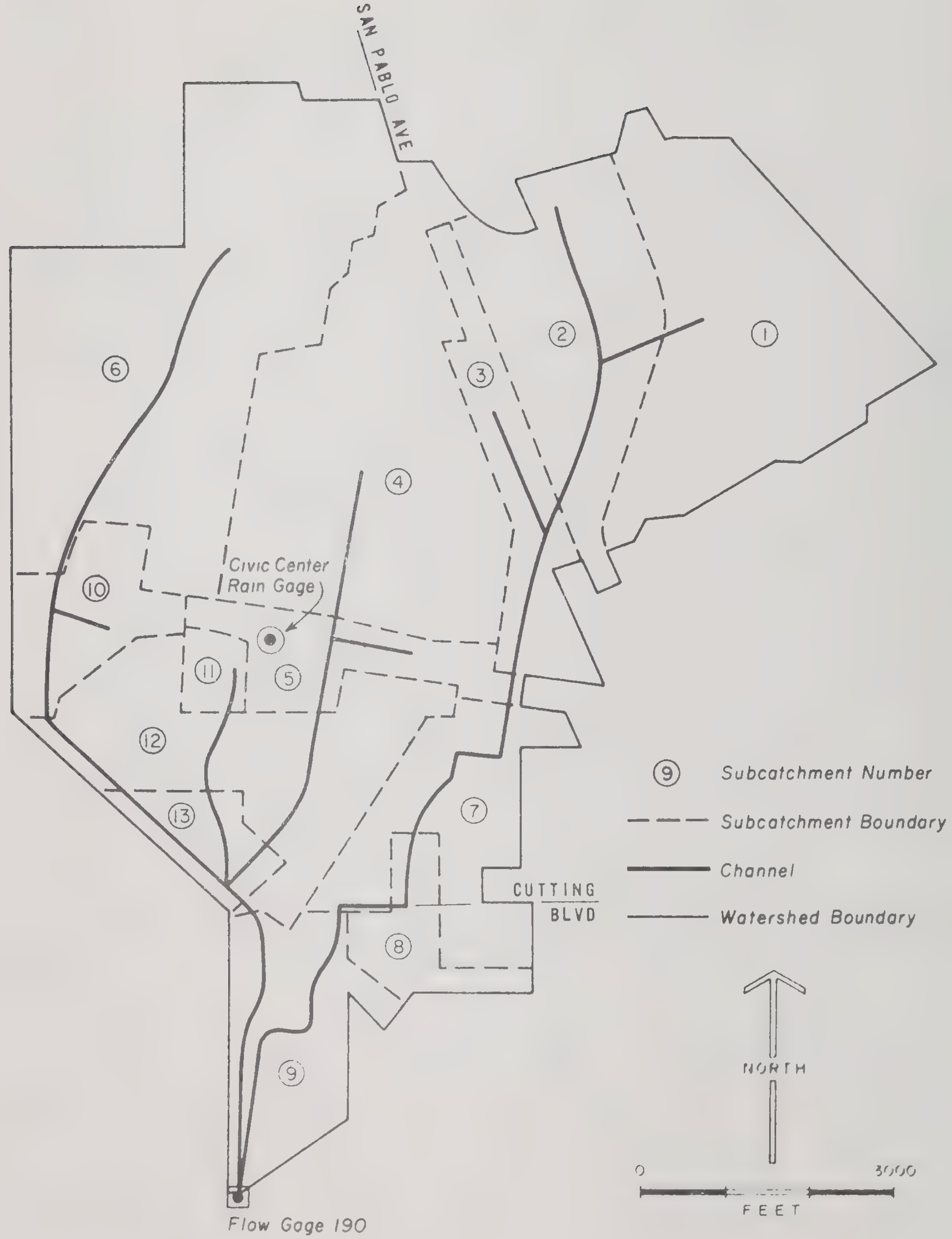
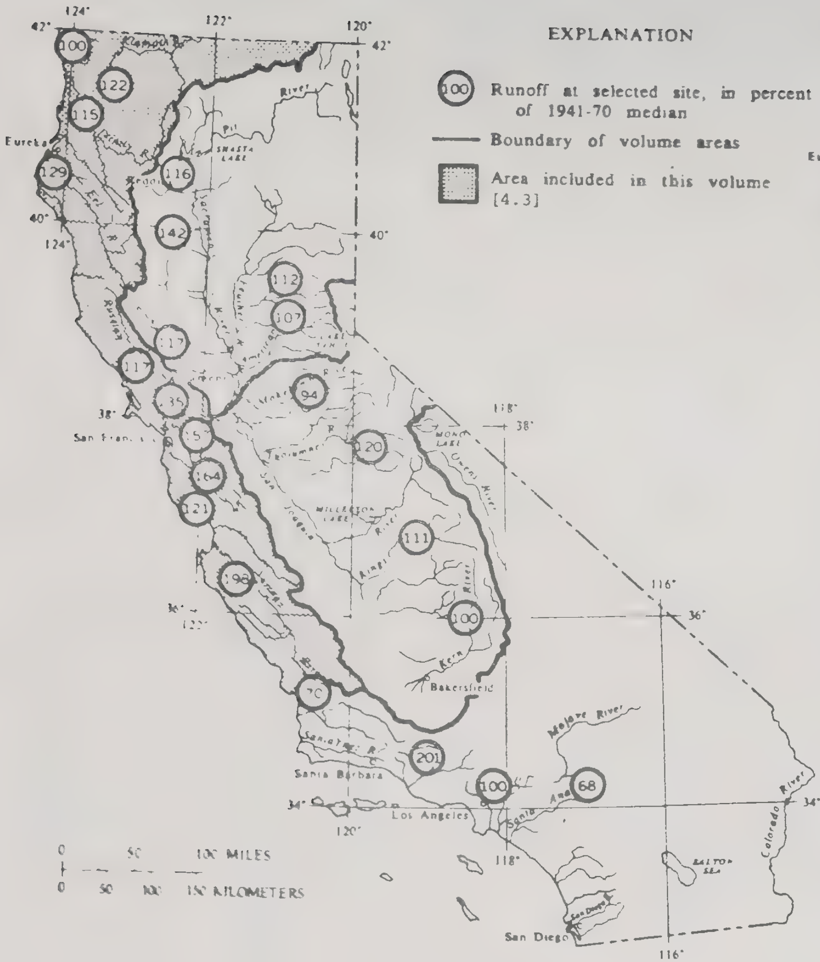
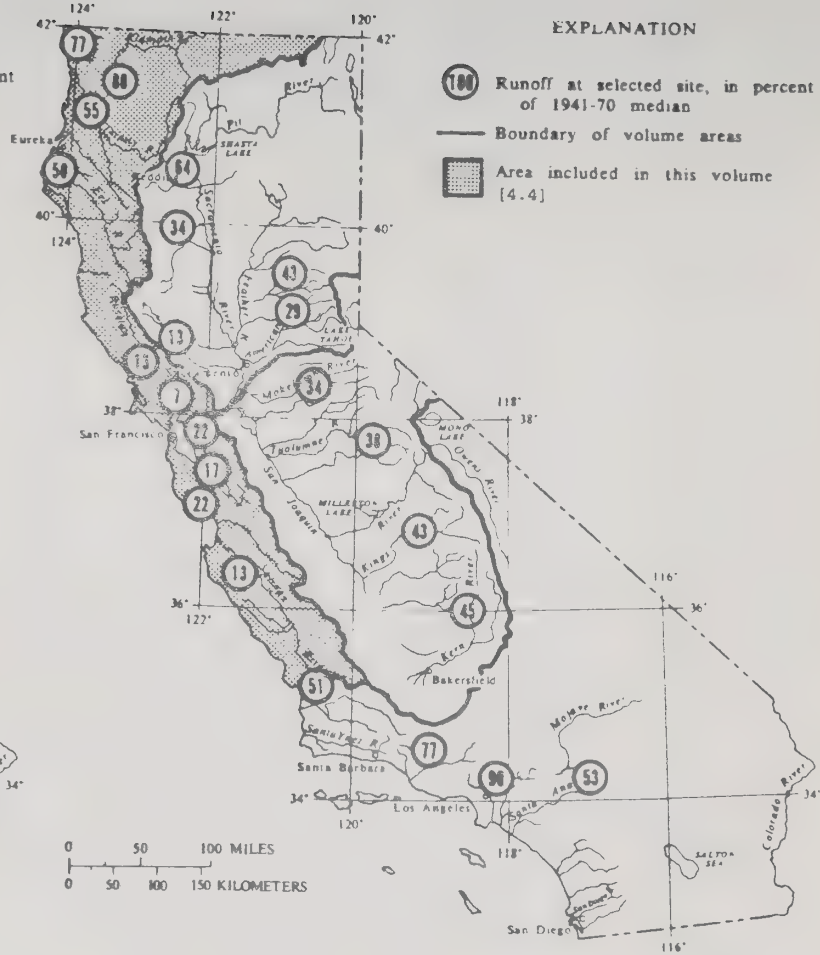


FIGURE 4-10. RICHMOND DEMONSTRATION WATERSHED



1975 WATER YEAR



1976 WATER YEAR

FIGURE 4-11. EXPERIENCED RUNOFF AS A PERCENTAGE NORMAL [4.3, 4.4]

The drought conditions posed many problems in the attainment and verification of local stormwater quantity and quality data. While, under the circumstances, much was accomplished, supplemental monitoring under nondrought conditions will be a critical requirement under continuing programs.

Quantity Coefficients for Modeling

MAC is structured to compute runoff as a direct multiple of rainfall and includes the option of varying the factor with land use; for example, a runoff coefficient for a paved parking lot may be 0.95 whereas for a field under cultivation it may be 0.05. However, these coefficients once set are held constant; thus, they do not reflect how wet or dry the particular surface was just prior to the storm. The result is a tendency to overestimate runoff in dry years and underestimate runoff in wet years. Representative starting coefficients are shown in Table 4-6. Improved estimates can be made by matching up average runoff yields against average annual rainfall on a watershed by watershed basis.

Table 4-6. MAC RUNOFF COEFFICIENTS, INITIAL VALUES

Land use	K factor
Residential	0.3
Multifamily residential	0.4
Commercial	0.7
Industrial	0.6
Open	0.2
Agricultural	0.1

SWMM does account for prestorm conditions; however, calibration based on dry year storms only would tend to introduce a bias of lower than "normal" runoff. Default values are built into the SWMM program to yield a first-cut approximation prior to calibration.

Quality Coefficients from National Sources

National experience in surface runoff monitoring is available from several sources. Three of the more comprehensive analyses are excerpted below.

The quality of urban runoff has been investigated at several sites across the country. The techniques, methodology, and goals varied from project to project, but the combined results present a good indication of the concentrations of pollutants that can be expected in urban runoff. The results of several representative sampling efforts are shown in Table 4-7. The samples were taken in various parts of the country, from diverse land use, during different seasons, and during dissimilar rainfall events. The average pollutant concentrations shown in the table indicate an order of magnitude of the stormwater runoff problem and the ranges indicate the wide variations in concentrations that may be anticipated. Averages were drawn from over 2,500 samplings [4.5].

Table 4-7. POLLUTANT CONCENTRATIONS IN STORMWATER RUNOFF [4.5]

City	Average pollutant concentrations, mg/L									
	TSS	VSS	BOD	COD	Kjeldahl nitrogen	Total nitrogen	Total phosphorus	OPO_4-P	Lead	Fecal coliforms[a]
Atlanta, Georgia	287	--	9	48	0.57	0.82	0.33	--	0.15	6,300
Des Moines, Iowa	419	104	56	--	2.09	3.19	0.56	0.15	--	--
Durham, North Carolina	1,223	122	--	170	0.96	--	0.82	--	0.46	230
Knoxville, Tennessee	440	--	7	98	1.9	2.5	0.63	0.32	0.17	25,600
Oklahoma City, Oklahoma	147	--	22	116	2.08	3.22	1.00	1.00	0.24	40,000
Tulsa, Oklahoma	367	--	12	86	0.85	--	--	0.38	--	420
Santa Clara, California	284	70	20	147	--	5.8	0.23	--	0.75	--
Pullach, Germany	158	53	11	125	--	--	--	--	--	--
Average (not weighted)	415	88	20	113	1.41	3.11	0.62	0.46	0.35	14,500
Range	147-1,223	53-122	7-56	48-170	0.57-2.09	0.82-5.8	0.33-1.00	0.15-1.00	0.15-0.75	230-40,000

a. Organisms/100 mL.

Another study [4.6] subjected the data from 20 cities and background values to statistical analysis with the results shown in Table 4-8.

Table 4-8. SUMMARY OF STORMWATER POLLUTANT CONCENTRATIONS

	Average pollutant concentrations, mg/L				
	TSS	BOD	COD	Total nitrogen	Total phosphorus
20 cities, storm sewers and unsewered areas					
Mean	608	27	205	2.3	0.5
Standard deviation[a]	616	25	118	1.4	0.4
Background from virgin land					
Range	2-100	0.5-3.0	--	0.05-0.5[b]	0.0-0.2

a. Approximately 70% of all values fall within the mean plus or minus one standard deviation.

b. Inorganic only.

In a third study, the University of Florida and the American Public Works Association working for the EPA to produce a "Nationwide Characterization" further identified, admittedly somewhat tenuously, a quality breakdown by land use and population density [4.7] which has been incorporated into MAC. There are some differences, however, due to data corrections, the assumptions for runoff volume, and the addition in MAC of undeveloped areas. Comparisons for an assumed population density of 20 persons/acre are shown in Table 4-9.

Table 4-9. COMPARISON BETWEEN UNCALIBRATED MAC AND REPORTED NATIONAL AVERAGE VALUES BY LAND USE
Average Pollutant Concentrations, mg/L

	BOD		SS		VS		PO_4[a]		N[b]	
Land use	MAC	NAT	MAC	NAT	MAC	NAT	MAC	NAT	MAC	NAT
Residential	12.9	14.6	262	297	153	174	0.6	0.6	8.7	2.4
Commercial	41.5	20.2	288	140	182	88	1.0	0.5	3.8	1.9
Industrial	15.8	8.9	378	214	187	105	0.9	0.5	3.6	2.0
Other developed	--	0.7	--	17	--	16	--	0.1	--	0.4
Other developed and undeveloped	0.2	--	5	--	5	--	0.0	--	0.1	--

a. As P.

b. As N.

Quality coefficients for SWMM are again built into the simulation in terms of experienced street dust and dirt characteristics. These terms may be adjusted in the calibration procedures.

Local Monitoring

In spite of the difficulties imposed by the drought, the first extensive surface runoff monitoring program was carried out involving 8 of the 9 counties. The test areas, storms, and samples are summarized in Table 4-10.

Table 4-10. ABAG MONITORING PROGRAM TEST AREAS 1976-1977

County	Watershed	No. storms	No. samples	Land use, %				
				Residential	Commercial	Industrial	Open	Agriculture
Alameda	Richmond	3	50	76	12	8	4	--
	Glen Echo	5	40	57	11	0	32	--
	Castro Valley	5	33	--	--	--	--	--
	Peralta	--	26	--	--	--	--	--
Contra Costa	Walnut Creek	5	9	35	13	2	50	--
	Pine Creek	5	11	24	1	1	74	--
	SR Rudgear	1	1	6	--	--	94	--
	SR @ WC	1	3	20	8	--	72	--
	Rheem	1	4	77	13	2	7	--
	Galindo	1	1	15	--	--	85	--
	LPC	1	1	--	--	--	100	--
Marin	Sleepy Hollow	4	41	20	--	--	80	--
Napa	York St	4	22	90	--	--	10	--
	Napa Creek	5	14	10	--	--	75	15
Santa Clara	Calabazas	5	65	38	14	2	46	--
	Santa Clara	3	40	--	--	100	--	--
	San Jose	3	36	--	100	--	--	--
	Guadalupe	2	25	33	11	3	54	--
	Matadero	3	28	--	--	100	--	--
	Berryessa	7	65	19	6	2	73	--
Solano	Green Valley	1	8	1	--	--	86	12
Sonoma	Sonoma Creek	2	6	2	0.4	0.6	89	8
San Mateo	Colma	1	1	27	9	12	52	--
	Serramonte	1	1	81	10	0	9	
	Bay Front	1	1	--	20	80		
	Brewster	1	1	100	--			

The available results through May 15, 1977, were averaged and grouped by predominant land use with the results shown in Table 4-11.

Table 4-11. LOCAL MONITORING RESULTS GROUPED BY PREDOMINANT LAND USE

Residential	%	Samples	Concentrations, mg/L BOD	SS	VSS	Total N	Total P	Population density
Alameda								
Castro Valley								
1971-1972	70(?)	36	6.7	904	--	2.0	0.7	--
1972-1973	--	59	31.0	945	--	3.7	0.8	--
1976-1977	70	33	25.7	339	--	--	--	21.4
Glen Echo	60	40	40.3	227	--	--	--	26.1
Peralta	--	26	24.9	--	--	2.7	0.7	--
Richmond	76	50	19.8	115	39	3.2	0.4	21.7
Contra Costa								
Pine Ck	23	11	--	--	--	--	--	--
Rheem	75	4	21.0	211	28	4.5	0.6	--
San Ramon at Walnut Creek	19	3	8.5	129	19	1.4	0.4	--
Walnut Creek	34(?)	8	8.8	132	23	2.7	0.6	11.4
Napa								
York Street	90	22	22.0	81	36	1.2	0.4	14.0
San Mateo								
Brewster	100	1	7.0	145	54	3.5	0.02	14.0
Colma	21	1	16.0	207	43	3.5	0.3	--
Serramonte	81	1	14.0	85	28	1.3	0.2	--
Santa Clara								
Calabazas	38	46	19.4	557	88	4.5	0.9	18.2
Guadalupe	33	32	27.0	461	98	6.4	0.8	16.7
Commercial								
Santa Clara-San Jose	100	36	21.1	158	67	7.0	0.7	--
Industrial								
Santa Clara-(light)	100	28	38.1	72	21	3.1	0.4	--
Santa Clara-(heavy)	100	37	13.0	114	45	4.5	0.3	--
San Mateo-Bay front	80	1	16.0	90	26	1.3	0.2	--
Open								
Contra Costa-SR-Rudgear	94	3	6.8	220	38	3.8	0.6	--
Contra Costa-Little Pine	100	1	9.7	5200	550	2.6	2.4	--
Marin-Sleepy Hollow	80	41	4.3	87	16	2.4	0.2	--
Santa Clara-Berryessa	73	80	8.0	1134	146	3.6	1.0	--
Open and Agricultural								
Napa-Napa Creek	90	14	13.0	1053	128	5.1	0.6	--
Solano-Green Valley	99	8	--	85	--	3.4	0.2	--
Sonoma-Sonoma Ck[a]	97	6	4.0	6	5	2.1	0.3	--

a. 4 days after storm

More detailed analyses of the 1976-1977 monitoring data were subsequently performed by ABAG and the results distributed with Surface Runoff Brief No. 2 dated June 22, 1977 [4.8]. Results of flow weighted concentrations of selected heavy metals and oil and grease extracted from the analysis are summarized in Table 4-12.

Table 4-12. LOCAL MONITORING RESULTS FOR SELECTED HEAVY METALS, OIL AND GREASE [4.8]

	Mean concentrations, mg/L									
Land use	Lead	Cadmium	Chromium	Silver	Nickel	Arsenic	Mercury	Copper	Zinc	Oil and grease
Residential	0.61	0.01	0.02	0.005	0.09	0.21	0.01	0.15	0.58	6
Commercial	0.85	--	--	--	--	--	--	--	--	28
Industrial	1.3	--	--	--	--	--	--	--	--	25
Open and agricultural	0.15	0.007	0.007	--	--	--	--	--	--	--

REFINEMENT AND CALIBRATION

Refinement of the model parameters was a continuing process due to overlapping programs of research, Series-3 projection development, site monitoring, test applications, and workshop instruction. As would be expected, MAC calibration emphasized judgmental decisions whereas statistical curve-fitting played a key roll in the more detailed SWMM.

MAC Calibration

MAC calibration requires local data and is performed in two steps: quantity and quality. One or more demonstration watersheds are used and the objective is to approximate reasonably annual average values and to test transferability. For example, in Santa Clara County, the Calabazas Creek (9,070 acres) watershed was used for calibration in conjunction with directly measured runoff from representative land use types. In the process, runoff coefficients were fixed for commercial and industrial areas based on the 1976-1977 season's observations.

Next, open and undeveloped area runoff was matched to the USGS estimate for the region and a set of both larger and smaller values. For each assumption, the residential (predominant land use) runoff was computed from the best (least squares) fit to 15 years of composite stream gage data. The resulting best overall fit is shown for long term (yearly) and short term (monthly) comparisons in Figures 4-12 and 4-13.

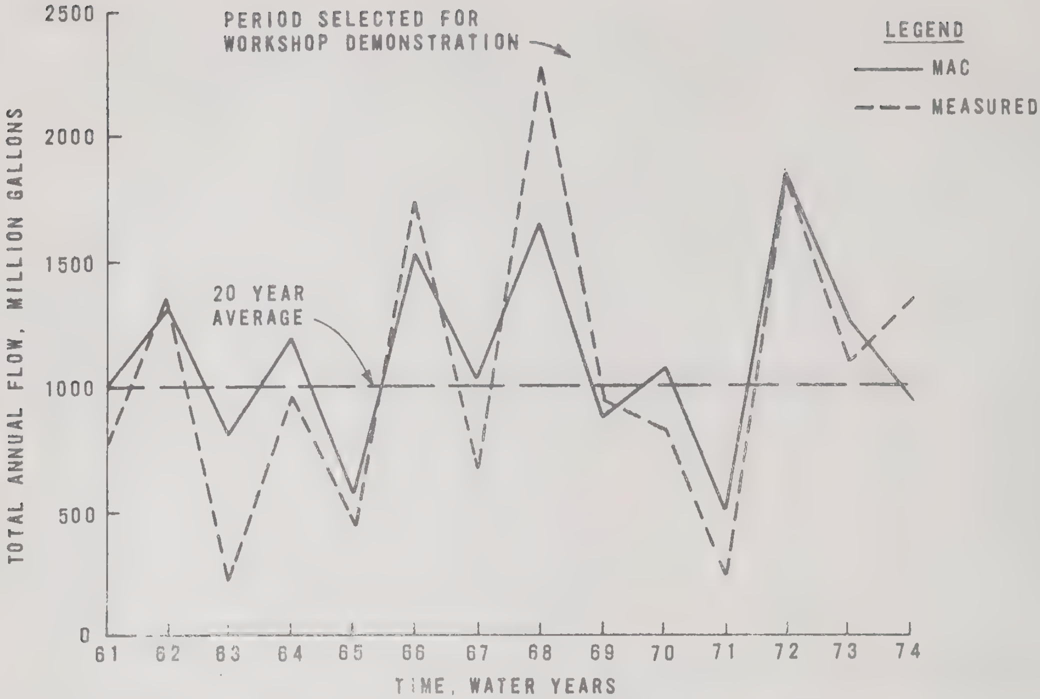


FIGURE 4-12. LONG-TERM COMPARISON OF MAC WITH MEASURED VALUES

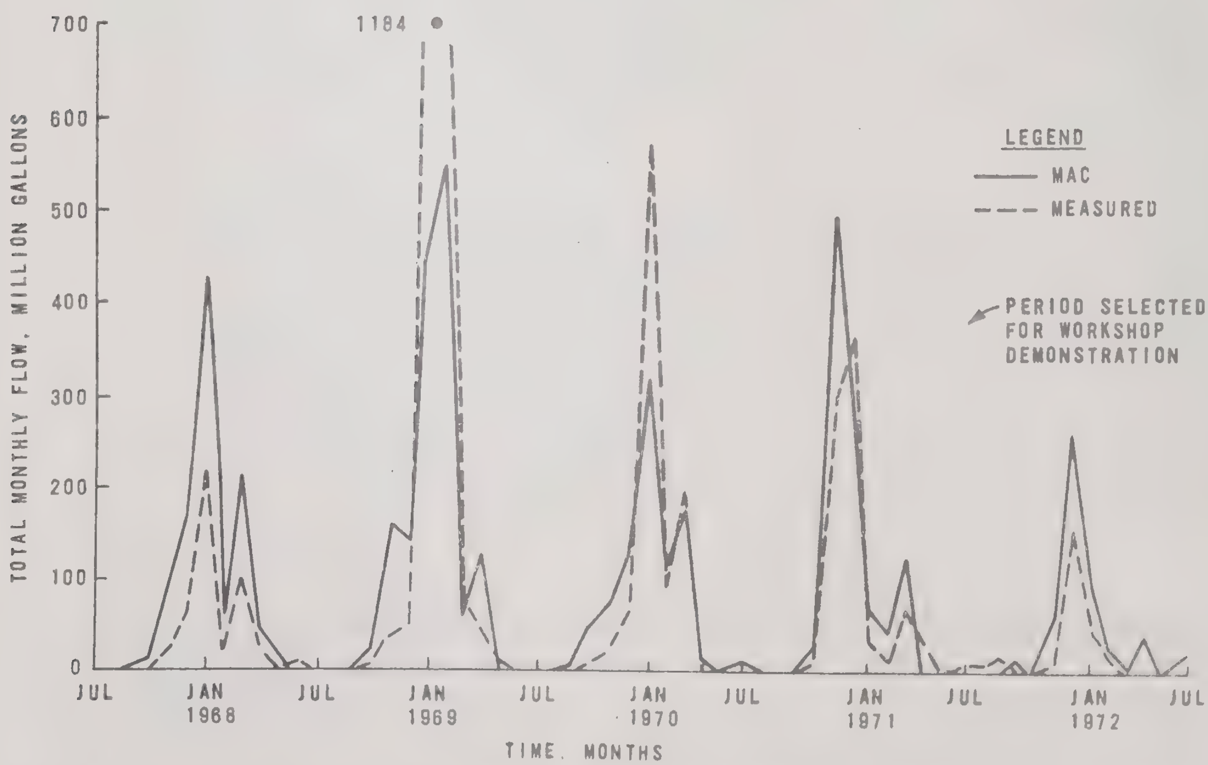


FIGURE 4-13. SHORT-TERM COMPARISON OF MAC WITH MEASURED VALUES

For quality calibration, flow weighted and arithmetic averages by sampling location were computed for the 259 samples collected within the county. Three of the test areas represented single land uses and thus the flow weighted concentrations could be substituted directly into MAC. These included commercial, industrial (light) and industrial (heavy). Because the 1976-1977 drought conditions yielded no measurable runoff from undeveloped open areas, the adjustments between residential and open were made weighing both the national data and the composite area local results. Results from the three data sets (initial MAC, revised National, and calibrated MAC) are shown along with the measured values for Calabazas in Table 4-13.

Table 4-13. COMPARISON OF MAC RESULTS TO MEASURED VALUES IN CALABAZAS WATERSHED mg/L

Item	Gross runoff, %	BOD	SS	VSS	Total N	Total P
Initial MAC	34.7	18.7	229	136	2.3	0.6
Revised National	27.2	13.5	174	104	1.7	0.5
Calibrated MAC	23.0	12.7	318	68	4.1	0.7
Measured 1976-1977	10.9	19.4	557	88	4.5	0.9
Measured (15-yr avg)	23.0	--	--	--	--	--

Calibrated MAC was also run on a second watershed of comparable area, Berryessa, and the results are compared to measured values in Table 4-14.

Table 4-14. CALIBRATED MAC TRANSFERRED TO BERRYESSA WATERSHED mg/L

Item	Gross runoff, %	BOD	SS	VSS	Total N	Total P
Calibrated MAC	16.8	8.5	430	63	2.5	0.4
Measured 1976-1977	4.9	8.0	1,134	146	3.6	1.0
Measured (5-yr avg)	34.0	--	--	--	--	--

In spite of the greatly simplified representation of real world phenomena, these MAC projections appear to be well within the order of magnitude assessment objective in certain parameters of interest, e.g., BOD and nutrients. Compared on an annual loading basis, the extreme range between test assumptions (high divided by low) is approximately 2 to 1 for all parameters. The high measured suspended solids concentrations from developed areas is believed related to the short duration of the drought events where sustained periods of relatively dilute runoff were rarely experienced.

The results of the calibration trials and the 1976-1977 monitoring program were reviewed with the counties and ABAG staff in a workshop and reduced to a working but still flexible consensus. The values in Table 4-15 are representative of the consultant's views for regional values, but are heavily handicapped by the abnormal rainfall runoff conditions during sampling.

Table 4-15. MAC QUALITY COEFFICIENTS FOR REGIONAL ANALYSIS
Concentrations in mg/L

Land use	BOD	SS	VSS	Total N	Total P
Residential	15	200	50	3.5	0.4
Residential, multifamily	20	300	75	3.0	0.3
Commercial	20	150	70	5.0	0.7
Industrial	13	120	50	3.0	0.5
Open	2	400	60	0.6	0.05
Agricultural	4	600	90	2.5	0.2

In addition, the difference between Glen Echo monitoring results and those from other areas is significant. Also, the characteristics of Glen Echo (older city core, densely settled and traveled) are quite different from those of the more recently developed watersheds such as Walnut Creek, Calabazas, Castro Valley, York Street, etc. A contributing factor in why older areas may be more prone to higher pollution in stormwater is the greater probability of indirect cross-connections with sanitary sewage either by overflows, faulted lines, illicit ties, or combinations. A similar condition may be responsible for the high values observed in the Guadalupe River downstream of central San Jose. To account for these observations in the regional analysis, BOD concentrations for the Lake Merritt and

Richmond major watersheds were increased 50% and San Jose-SW 10% based on the proportion of older core city areas to the total watershed. Values for combined sewer overflows from San Francisco were taken from measured long-term averages in the City (BOD, 68 mg/L and SS, 180 mg/L).

SWMM Calibration

The calibration and verification of SWMM for selected storms and demonstration watersheds is described in detail in an earlier RMA report [4.9]. The calibration procedure followed the general principles outlined in Section 3 and was based on flow and quality data compiled from ABAG 208 monitoring program results and from historical records obtained from the Corps of Engineers, the USGS, and other agencies. A list of the storms and data sources used in the SWMM calibration/verification is provided in Table 4-16.

A question which frequently arises in model calibration/ verification studies and which is particularly relevant in the case of the ABAG surface runoff study is "how much field information is needed to provide a statistically valid evaluation of model performance?" It is obvious that even a very crude model can be adjusted to pass through two or three scattered data points. A meaningful comparison of simulated results with field measurements is possible only when a relatively large number of field samples are available. A simple rule of thumb is that the number of flow or quality samples should be at least three times the number of unknown flow or quality coefficients adjusted during calibration. Since surface runoff monitoring is expensive and subject to the vagaries of the weather, field samples for model calibration/verification are rarely plentiful and sometimes nonexistent. Consequently, statistically valid calibration and verification are not always possible. Although mitigation measure evaluations can be carried out in the absence of verification data, they will understandably be less reliable than they would be if field data were available.

Fortunately, enough data were available to provide a statistically acceptable evaluation of SWMM effectiveness for 9 of the 12 demonstration watersheds used in the ABAG surface runoff study. Typical adjustments made in model coefficients in order to obtain better agreement between model results and field data for these 9 watersheds are listed in Table 4-17. This table indicates that detention depths were significantly overestimated and infiltration rates were significantly underestimated prior to calibration. Most of the other initial estimates were reasonably good.

Table 4-16. SUMMARY OF STORMS AND DATA SOURCES USED FOR THE SWWM CALIBRATION/VERIFICATION

Watershed/ storm date	Duration, hr	Peak rainfall intensity, in./hr	Peak stream flow, ft^3/s	Data sources			Number of measurements	
				Rain	Flow	Quality	Flow	Quality
Glen Echo Creek								
12/29-30/76	6.0	0.2	62	Alameda County 208 monitoring program	Alameda County 208 monitoring program	Alameda County 208 monitoring program	20	7
1/2/77	6.3	1.4	76	Alameda County 208 monitoring program	Alameda County 208 monitoring program	--	15	--
3/15/77	3.5	0.2	59	Alameda County 208 monitoring program	Alameda County 208 monitoring program	Alameda County 208 monitoring program	13	5
Richmond								
2/8/77	5.0	0.2	35	Special ABAG 208 monitoring program	Special ABAG 208 monitoring program	Special ABAG 208 monitoring program	13	13
2/20/77	4.0	0.1	27	Special ABAG 208 monitoring program	Special ABAG 208 monitoring program	--	18	--
3/15/77	12.5	0.3	77	Special ABAG 208 monitoring program	Special ABAG 208 monitoring program	Special ABAG 208 monitoring program	25	17[a]
York Street								
2/21/77	7.0	0.3	5	Napa County Yountville gage	Napa County 208 monitoring program	Napa County 208 monitoring program	7	5
3/15/77	12.0	0.2	4	Napa County Yountville gage	Napa County 208 monitoring program	--	8	--
Castro Valley Creek								
3/21/77	8.0	0.6	460	Corps of Engineers special monitoring program	Corps of Engineers special monitoring program	Corps of Engineers special monitoring program	22	9
2/20/77	2.5	0.4	166	Corps of Engineers special monitoring program	Corps of Engineers special monitoring program	Corps of Engineers special monitoring program	8	6
3/15/77	8.5	0.2	168	Corps of Engineers special monitoring program	Corps of Engineers special monitoring program	--	17	--
Calabazas Creek								
12/29-30/76	7.5	0.4	210	Perm. Santa Clara County gages	Santa Clara County 208 program	Santa Clara County 208 program	--	10
1/2/77	8.0	0.8	509	Perm. Santa Clara County gages	Santa Clara County 208 program	--	--	--
3/21/75	11.0	0.8	696	Perm. Santa Clara County gages	Santa Clara County 208 program	--	--	--
Colma Creek								
11/7/75	4.5	0.4	405	San Mateo County Public Works	USGS	--	11	--
3/15/77	10.0	0.3	5.5	San Mateo County Public Works	USGS	San Mateo County 208 program	22	10[b]
Napa Creek								
2/21/75	10.0	0.6	2,400	Napa County Yountville gage	USGS	--	11	--
Sonoma Creek								
12/20/69	9.0	0.4	3,400	Sonoma County Water agency records (USGS stream gage)	Sonoma County Water agency records (USGS stream gage)	--	27	--
12/24/68	16.0	0.2	1,320	Sonoma County Water agency records (USGS stream gage)	Sonoma County Water agency records (USGS stream gage)	--	27	--
3/21/75	12.0	0.5	6,910	Sonoma County Water agency records (USGS stream gage)	Sonoma County Water agency records (USGS stream gage)	--	39	--
Green Valley Creek								
12/30/76	23.0	0.3	21	Solano County 208 program	Solano County 208 program	--	9	--
1/2/77	25.0	0.3	32	Solano County 208 program	Solano County 208 program	--	9	--

a. Only 11 BOD measurements available for 3/15/77.

b. Constituents measured: Suspended solids, phosphorus, lead.

Table 4-17. SUMMARY OF SWMM COEFFICIENT ADJUSTMENTS OBTAINED DURING CALIBRATION

Type of Coefficient	Typical initial estimates			Typical adjustments due to calibration, %		
	Large Watersheds	Medium Watersheds	Small Watersheds	Large Watersheds	Medium Watersheds	Small Watersheds
Imperviousness, %	5.0	.25	40.0	+15	-10	-10
Detention depths, in.	0.18	0.10	0.06	--	-70	-80
Overland manning coefficients	0.25	0.10	0.01	--	--	--
Infiltration rate (pervious areas), in./hr	0.05	0.05	0.05	+50	+50	+100
Channel manning coefficients	0.03	0.01	0.01	--	-10	+10
Dust and Dirt (D&D) factors, lb/d/100 ft of curb	1.5	2.0	3.0	--	+20	+20
Suspended solids fractions of D&D mg/g	1,000	1,000	1,000	--	+5	--
BOD fractions of D&D, mg/g	5.0	6.0	6.0	--	--	+60
Nitrogen fractions of D&D, mg/g	0.05	0.5	0.5	-50	-50	--

A summary of model performance for typical storms simulated on each of the watersheds is given in Table 4-18. This summary table indicates that SWMM does quite well in reproducing measured flows in the watersheds of interest. The greater uncertainty encountered in water quality prediction is to be expected, since contaminant generation is not understood as well as surface water hydrology. The quality results are, however, good enough to justify a relative evaluation of the effectiveness of alternative control measures.

Table 4-18. SUMMARY OF SWMM PERFORMANCE FOR TYPICAL DEMONSTRATION WATERSHED VERIFICATIONS

Watershed/ storm date	Flow peak, ft^3/s		Flow peak, clock hr		Suspended solids peak, mg/L		Suspended solids peak time, clock hr	
	Measured	Simulated	Measured	Simulated	Measured	Simulated	Measured	Simulated
Glen Echo Creek 12/29-30/76	64	60	2230	2236	900	600	2130	2100
Richmond 2/8/77	35	26	1236	1224	180	220	1142	1212
York Street 3/15/77	4	6	0600	0700	180	170	0614	0530
Castro Valley Creek 3/21/75	460	520	1900	1900	290	120	1600	1600
Calabazas Creek 12/29-30/76	210	280	0130	0030	1,000	1,000	0212	2300
Colma Creek 3/15/77	515	640	1600	1700	400	260	0942	1112
Napa Creek 3/21/75	2,400	2,350	1900	1900	--[a]	--	--	--
Sonoma Creek 12/20/69	3,400	4,500	0712	0712	--	--	--	--
Green Valley Creek 12/30/76	21	45	2100	2200	--	--	--	--

a. Measured quality data not available.

MITIGATION MEASURE SIMULATION

Mitigation measure success can be defined as the net reduction, redistribution, or nongrowth of an identified pollutant discharged from the watershed. Through the Environmental Management Task Force - Technical Advisory Committee discussions, additional criteria were set to ensure that the measure is low in cost and that it is feasible to implement.

Net pollutant reductions result from (1) the reduction or diversion of runoff, such as provisions for increased percolation into the ground through spreading basins, porous channels, velocity controls, etc.; (2) the reduction of storm pickup of pollutants such as implementing improved housekeeping practices, legislative prohibitions of the sale and use of harmful chemicals, public education programs, best watershed management practices (e.g., erosion controls, greenbelts, revegetation, check dams, etc.); and/or (3) the treatment of a portion of the flow, such as routing and temporary ponding of flows through marshlands, storing and

diverting certain flows through existing or new treatment facilities, or, rarely, through the installation of instream, high-rate treatment devices.

The extent that surface runoff management plan scenarios can be described and quantified in these categories largely determines the effectiveness of the model simulations and their value in plan assessments. Examples of SWMM-MAC applications in each of the three categories were presented in a user workshop [4.10]. Where possible, the SWMM model was applied first on a representative demonstration watershed to develop appropriate MAC coefficients and then MAC was run to expand the results to subregional or regional impacts.

SWMM Application

The simulation of mitigation measures with SWMM was briefly discussed in Section 3, where a number of measures of potential interest to the ABAG region were explicitly related to SWMM model inputs. Although SWMM can investigate any of these mitigation measures, county personnel expressed interest only in street sweeping and erosion control. These were, consequently, the only mitigation alternatives simulated. A typical SWMM mitigation measure assessment is illustrated in Figure 4-14 where three different levels of street sweeping are compared for their effects on BOD in the Glen Echo watershed. The four plots shown in this figure represent the following conditions:

a) Flow hydrograph at discharge point 190

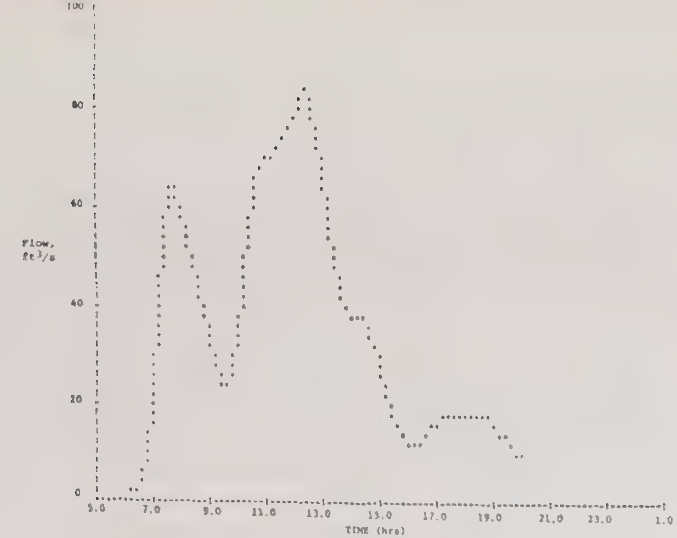
b) BOD for nominal street sweeping frequency of 1 pass every 3 weeks

c) BOD for increased street sweeping frequency of 1 pass every week

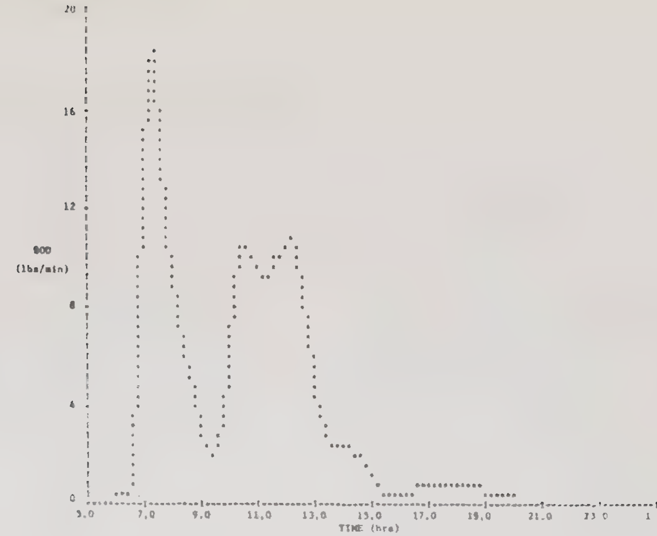
d) BOD for further increased frequency of 2 passes every 3 days

The BOD pollutographs show a nearly linear decrease in both BOD peak concentration and total BOD mass load as street sweeping effort (number of passes/week) increases. These results apply to a storm which occurs after a prolonged dry period (early fall). During the rainy winter season, the relative improvement obtained by increased street sweeping effort is not as great.

A set of plots such as those in Figure 4-14 can be used to evaluate the overall benefit (in terms of mass of contaminant removed) of street sweeping for a range of different storms and antecedent conditions. A comparison of

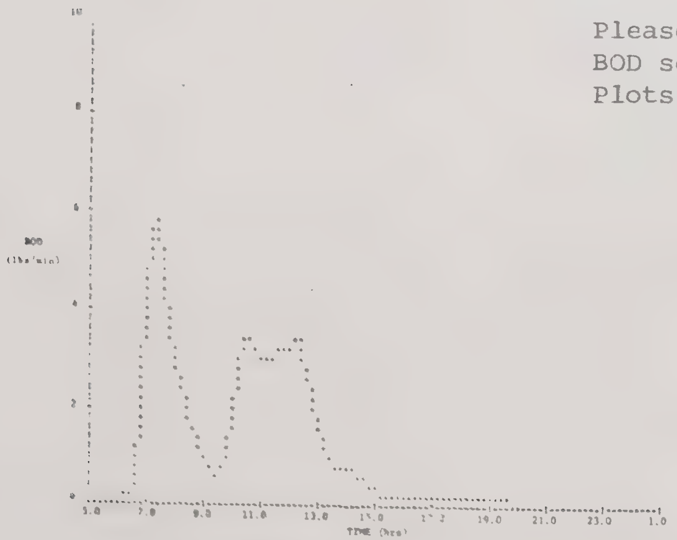


a) Flow at Glen Echo
Stream Gage (Node 190)

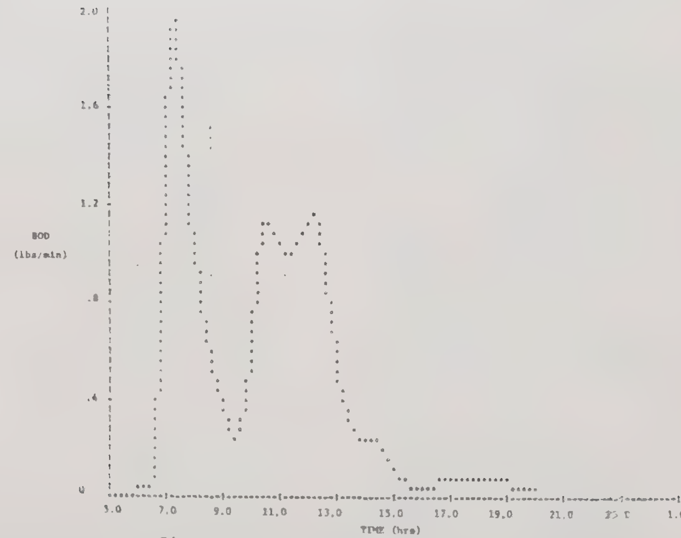


b) BOD Mass Load for 1 Pass
Every 3 Weeks

Please note change of
BOD scale between
Plots b), c), and d).



c) BOD Mass Load for 1 Pass
Every Week



d) BOD Mass Load for 2 Passes
Every 3 Days

FIGURE 4-14. MITIGATION MEASURE ASSESSMENT OF
STREET-SWEEPING ALTERNATIVES FOR THE GLEN ECHO WATERSHED

this benefit with street sweeping cost will then help determine the attractiveness of expanded street sweeping as a mitigation measure. Similar comments apply to other measures such as erosion control. Further information on mitigation measure evaluations for demonstration watersheds in the ABAG study area is provided in Section 5.

MAC Application

The key outputs of a calibrated MAC watershed are the volume of runoff and the mass loadings of pollutants. The equations that define the output are:

$$\text{Runoff volume} = \Sigma^{n}, \text{ KPA}$$
$$\text{Mass loading of pollutant X} = \Sigma^{n}, \ 0.227 \text{ KPAC}_{x}$$

where K = dimensionless runoff coefficient
P = precipitation, in.
A = area, acres
C_x = average concentration of pollutant X, mg/L
n = number of land use types in watershed, each with its own runoff coefficient, precipitation record, area, and average pollutant concentration
0.227 = constant conversion unit for pollutant load, lb

Looking at these relationships, it is seen that options increasing infiltration can be simulated by decreasing the value of "K" and consequently decreasing both runoff volume and pollutant loading. Alternatives that will decrease pollutant loading on the land surface are simulated by decreasing the "C" value for a specific pollutant and land use. Finally, all or part of the runoff from a subarea can be put through a subroutine that simulates storage or treatment. The storage part controls the rate of runoff from an area but does not affect the volume or pollutant loading. The treatment option reduces the pollutant concentration to a specified value simulating the chosen treatment option.

In applying MAC for mitigation measure assessment, a simple five step procedure was recommended:

1. Compute MAC coefficients based on SWMM runs or other specific source.

2. Specify runs that are to be made with MAC:

   - Existing conditions
   - Future conditions - 1985
   - Future conditions - 2000
   - Specific watershed affected

3. Enter coefficients into MAC program and initiate runs.

4. Summarize output.

5. Draw conclusions concerning impact.

As a means of illustration, three examples were developed using the Calabazas demonstration watershed. In Example 1, the effectiveness of maintenance measures was tested through improved street sweeping practices in the urbanized portions of the watershed. In Example 2, the potential effectiveness of erosion control practices was tested through cropping management changes and installation of a small control structure. Finally, in Example 3, the use of an existing flood control basin/marsh area for surface runoff treatment was assessed. Partial results are summarized in Table 4-19.

Table 4-19. SWMM-MAC MITIGATION MEASURE ASSESSMENT ON A DEMONSTRATION WATERSHED [4-10][a]

Description	Net flow Reduction, %	Net pollution reduction, %		
		BOD	SS	Lead
Example 1, street sweeping	0.0	13.7	3.0	27.3
Example 2, erosion control	0.0	>1.0	21.4[b]	>1.0
Example 3, flood basin/marsh treatment[c]	0.0	31.6	59.5	26.3

a. Calabazas watershed 1975 conditions.

b. Some SWMM runs showed single storm improvements as high as 80%.

c. Flood basin relocated from Palo Alto to Calabazas watershed for purpose of example.

Thus, it can be seen that if the pollutant (e.g., lead) is dominantly associated with street solids, improvement of sweeping efficiency will obviously be effective. However, where the source material is scattered throughout a watershed (e.g., SS) street sweeping may have negligible effect. Of the three, flood basin/marsh management appears extremely attractive.

RECEIVING WATER IMPACTS

Transfers of MAC output files to the receiving water simulator was developed into a comparatively simple procedure. First, 41 transfer nodes were identified giving consideration to the MAC major watersheds, primary creeks

and streams, and available estuarine nodes. These transfer points are identifed in Figure 3-7. Next, average annual loadings to each transfer point were computed using MAC under specified conditions of development and mitigation measures in effect.

The receiving water models then converted the surface runoff loadings into a uniform 3-day "design" storm which aggregated to 0.10 of the annual totals. Appropriate municipal and industrial point sources were then input to the model at the same or adjoining nodes and the simulator run for a 5 to 10 day simulations with the results displayed at preset time intervals. Other parameters and assumptions are noted in a paper by Frommer et al. [4.11]. Example results are reported in the next section.

Section 5

PROGRAM RESULTS

Is surface runoff a threat to the water quality of San Francisco Bay, its tributaries and inland reservoirs? Are impacts increasing or regressing? Localized or wide spread? Limited to a few quality constituents or across-the-board parameters? Are potentially adverse conditions or trends reversable? At what cost and through what mechanism? These questions and others of a more political tone are representative of the challenges faced, and to a creditable extent, responded to by the eight county Surface Runoff Management Plans in a single year's intensified program.

In this section, modeling highlights from the county plans are assembled, a modified regional analysis is undertaken and presented, and the sensitivity of certain selected model parameters is explored. Conclusions and recommendations for continuing programs are presented in Section 6.

COUNTY ANALYSES

The first, and one of the most important, product of the county plans is the disaggregation of the study area into watersheds and subarea classified zones. The results, composited on a regional scale, are shown in Figure 5-1. The map, at a glance, displays several important things: where development is concentrated now; where it is likely to spread; and where and in what proportion the buffer or natural and protected areas are located. Less obvious, but also available when used in conjunction with the MAC subarea definition in Table 4-1 and Figure 3-7, are the flow routing hierarchies and receiving water discharge zones for each point in the study area. For example, a large industrial complex shift to Livermore would impact not only the B and C zones surrounding the city itself but also down the Niles Canyon through de la Laguna A5; Lower Alameda Creek subareas A, B, and C; and South San Francisco Bay Node 040.

Potential areas of concern, evident on this scale, might include the identified development potential in South Santa Clara Valley (because of the area's remoteness from high volume receiving waters) and in extreme eastern Contra Costa County (because the discharge would be to the ecologically sensitive Delta). Future refinements in subarea designations might include the designation of potentially developable lands in Marin (e.g., Lagunitas Creek A-2--Nicasio Reservoir watershed--has since been studied for

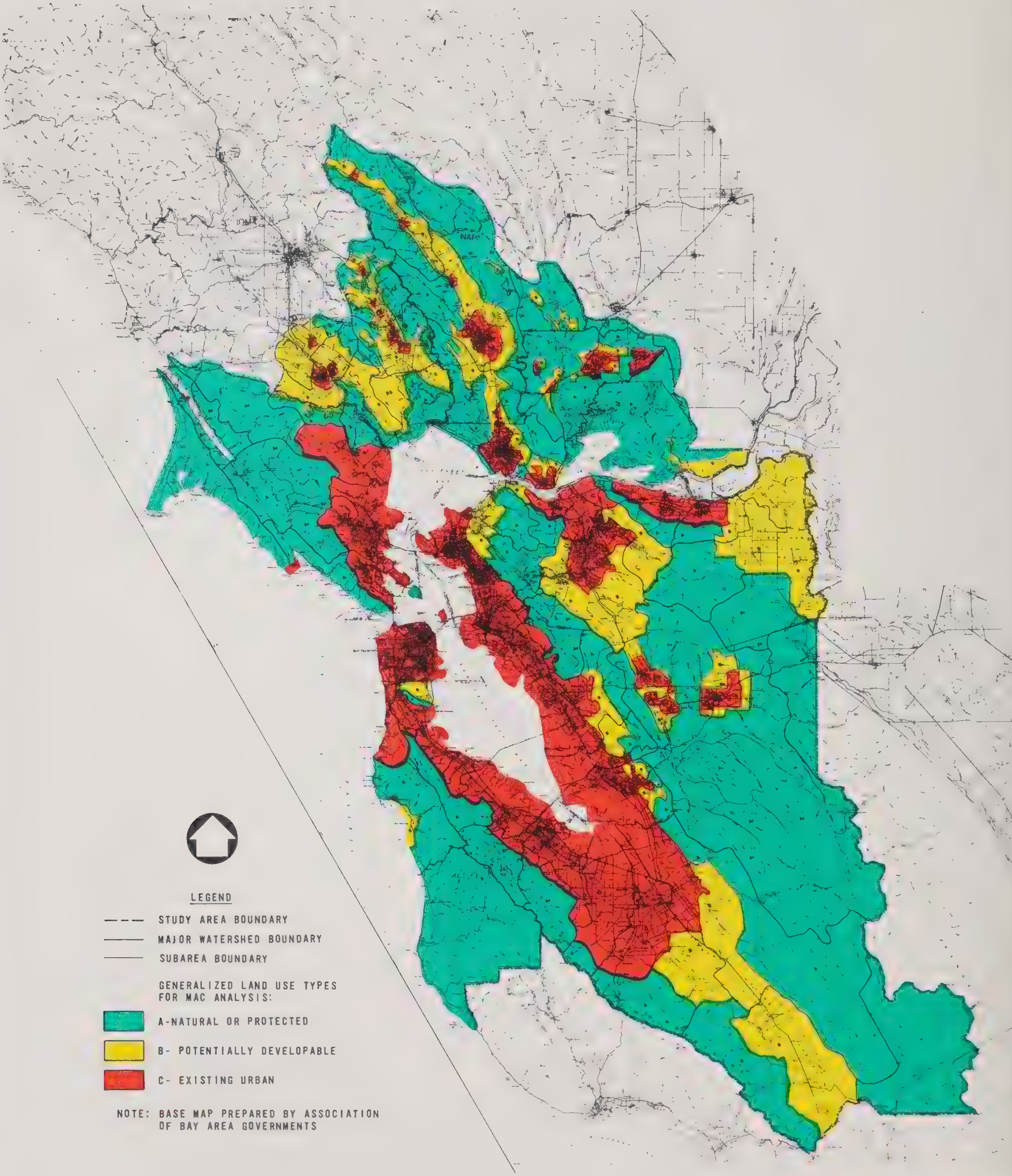


FIGURE 5-1 MAC WATERSHEDS EMPHASIZING GENERALIZED LAND USE - 1975

possible development [5.1]) and the redesignation of certain lands around South San Francisco Bay from existing urban to potentially developable or natural or protected (e.g., designated wildlife refuge). It should be noted, however, that the general land use classification Types A, B, and C are illustrative only and have no impact on the numerical results which are controlled by specific land use breakdowns.

MAC Factors

Factors used by the various counties in the MAC simulations for problem assessment are summarized in Table 5-1. The largest differences, not unexpectedly, occur under the open land use classification where information, as a result of the drought years, varied from sparse to nonexistent. Runoff coefficients for open land use were highest for Marin and Napa and lowest for Contra Costa and Santa Clara. Quality coefficients generally adhered to the consensus developed in Surface Runoff Workshop 4 [5.2], but in terms of loadings to San Francisco Bay were heavily biased toward the open space assumptions. Open space suspended solids assumptions varied from a low of 150 mg/L in Napa County to a high of 1,450 mg/L in Alameda County (Upper Alameda Creek).

Existing and Projected Loadings

Existing and projected surface runoff loadings were prepared by each county and compared against point source loadings. This information is presented in the various county plans and has been summarized by ABAG [5.3, 5.4]. Significant findings include the following with comments added:

1. Surface runoff loadings on a regional scale do not change dramatically in projections to 1985 and 2000. This is believed to be a direct result of the buffer capacity built into the 87% open land use classification as introduced in Section 4 and to the modest population growth forecasts, less than 1% per year average over the next 25 years.

2. Surface runoff loadings in terms of BOD are relatively small when compared to point source discharges today, but will nearly equal point sources in magnitude when full secondary treatment of point sources is in effect.

3. Surface runoff loadings in terms of nutrients are nominally 5 to 15% as great as point sources, but can prove to be a major factor in the eutrophication of inland lakes and reservoirs where point sources are traditionally excluded.

Table 5-1. FACTORS USED IN MAC SIMULATION FOR PROBLEM ASSESSMENT

Item	Alameda	Upper Alameda	Contra Costa	Marin	Napa	San Mateo	Santa Clara	Solano	Sonoma
K factors									
Residential	0.3-0.4	0.3	0.2-0.4	0.31	0.3-0.4	0.25-0.58	0.24	0.3	0.41-0.42
Multi-residential	--	--	0.4-0.5	0.55	--	--	--	0.5	0.41-0.42
Commercial	0.7	0.7	0.6	0.75	0.3-0.7	0.6	0.5	0.9	0.8
Industrial	0.6	0.6	0.5-0.6	0.75	0.3-0.5	0.7	0.6	0.9	0.6
Open	0.15-0.17	0.15-0.17	0.11-0.20	0.26-0.30	0.25	0.15	0.12	0.2	0.17-0.21
Agricultural	--	--	--	0.15	0.25	--	--	0.2	--
Overall total Bayside	22.9	14.6	17.4	30.7	23.2	26.2	22.2	22.3	16.6
BOD, mg/L									
Residential	15-33	15	10.9-19.6	15	15	15	15	15	15
Multi-residential	--	--	12.6-19.6	10.4-11.4	--	--	--	17.7	15
Commercial	20	20	20	20	20	20	20	20	20
Industrial	13	13	13	13	13	13	13	13	13
Open	4	1-4	4	4	4	4	4	4	4
Agricultural	--	--	--	--	--	--	--	4	4
SS, mg/L									
Residential	200	200	182.5-327.25	100	100	200	200	200	200
Multi-residential	--	--	182.5-327.5	211.5-232.5	--	--	--	359.6	200
Commercial	150	150	150	150	150	150	150	150	150
Industrial	150	150	120	120	120	120	120	120	120
Open	400-500	500-1,450	200	400-600	150	175	600	500	350-500
Agricultural	--	--	--	--	350	--	--	500	--

4. Surface runoff loadings are a major source of suspended solids and sediment in the Bay and its tributaries, but even greater loadings are introduced through Delta outflows.

5. Surface runoff loadings in terms of heavy metals and toxicants may be the most significant adverse impact but again data on the probable loadings and impacts in the Bay are quite speculative and sparsely documented.

6. Finally, bacterial contamination and continued loss of shellfish resources may be a significant impact from surface runoff discharges.

<u>Mitigation Measure Assessment</u>

The site specific mitigation measure studies conducted with SWMM give an indication of the relative effectiveness of street sweeping and erosion control alternatives on particular demonstration watersheds in the ABAG study area.

The assessments of <u>relative</u> effectiveness provided by these studies can be generalized to other watersheds of similar size, land use, and hydrologic composition even though the absolute levels of contaminant reduction predicted may not be transferable. When the results of the SWMM mitigation measure evaluations are combined with those of MAC, a good indication of overall effectiveness (local and regional) can be obtained.

A summary of SWMM mitigation measure assessments for three watersheds of different sizes is given in Table 5-2. These summary results indicate that increased erosion control, particularly installation and maintenance of additional sedimentation basins in many less developed watersheds of the San Francisco Bay region, could result in a significant decrease in solids loads to the Bay. The attractiveness of this mitigation measure depends, of course, on the benefits of reduced solids loads and the costs of an extensive sedimentation control program. In more developed urban areas, increased street sweeping can provide a significant reduction in contaminant loads, particularly in BOD loads from commercial and high density residential areas. This mitigation measure appears to be an attractive one, particularly in those areas where an existing street sweeping program can be expanded with relative ease.

Table 5-2. SUMMARY OF SWMM MITIGATION MEASURE ASSESSMENTS

Watershed type/control measures investigated	Summary of simulation results
Small urban watersheds (Glen Echo)	
Street sweeping	Suspended solids and BOD loads decrease almost linearly with increases in the number of passes per week. A street sweeping frequency of one pass per week could reduce coliform loads to Lake Merritt to about 25% of existing levels.
Roof top detention	The initial "first flush" peak of the BOD pollutograph is reduced by 30% when watershed-wide rooftop detention on commercial buildings is instituted. Coliform and solids loads appear to be reduced only slightly by this mitigation measure.
Medium mixed land use watersheds (Calabazas)	
Street sweeping	A twofold increase in number of passes per week throughout the watershed will give a 20-30% reduction in BOD loads and somewhat less in suspended solids. A larger increase (at least three-fold) will be needed to counterbalance anticipated increases in the countywide BOD load due to population growth.
Erosion control	Improved maintenance of hillside grasslands and construction of small sedimentation basins in the upper watershed will reduce total suspended solids loadings by nearly 80%.
Large rural watersheds (Sonoma, Napa)	
Erosion control	Installation of additional sedimentation basins in the upper reaches of either the Napa or Sonoma Creek watersheds could provide a significant (up to 60%) reduction in total solids load. If this mitigation measure were adopted in all major watersheds of the Napa and Sonoma valleys, a sizeable decrease in suspended solids loads delivered to San Pablo Bay during storm periods could be obtained.

Unfortunately, most county studies were terminated short of quantifying mitigation strategies; thereby relegating this work to the continuing planning process.

REGIONAL ASSESSMENT

To round out the work program started by ABAG, Metcalf & Eddy performed a modified regional assessment in which essentially all MAC factors were fixed for the region as a whole and reapplied to each of the 127 MAC subareas. The factors selected were those recommended as starting points in Section 4 with adjustments for San Francisco, Lake Merritt, Richmond, and San Jose southwest made as discussed. The purpose of the standardization was to remove human judgments, which were so important to the intracounty analyses, from the regional assessment because of the potentials for introducing a biased effect through the variance in approaches between counties.

Pre- and Post-Development Loadings

Because of the uncertainties of the flows and loadings from the open and undeveloped areas, two complete runs were made. In the first, development was mathematically rolled back to the early 1800s or natural stage by fixing all land use coefficients to the values selected for open areas. This is assumed to be representative of the predevelopment natural or background loading. The second run was based on the developed land use descriptions as they existed in 1975. The loading results summed by major watersheds are listed in Table 5-3.

Gross total loadings to the Bay under predevelopment and developed conditions from surface runoff alone are summarized in Table 5-4. It can be seen that organic loadings have probably increased about 6-fold and nutrients about 4- to 5-fold while total solids have remained relatively unchanged. Thus it appears that the Bay, as in most shallow embankments, has always been turbid and no actions by man will likely reverse this condition. With respect to dissolved oxygen, the combined actions of Bay filling and increased organics discharged have, no doubt, worsened conditions in backwaters and areas of poor circulation. While nutrient loadings have grown substantially, their impact when compared to point discharges remains small.

The regional distribution of loadings is suggested in Figure 5-2 where discharge arrows are scaled proportionally to calculated average annual BOD load. It is interesting to note that loadings to the lower South Bay (south of San Mateo Bridge), where circulation is poor, have increased 3.3 times above estimated predevelopment levels and now account for 24% of the total surface runoff loading to the Bay (6.8% if Delta outflow [5.5] is included).

Table 5-3. REGIONAL ASSESSMENT LOADING RESULTS BY MAJOR WATERSHED

County and major watershed	Discharge location[b]	Average annual discharge loading, 1000s lb[a]							
		BOD		SS		Total nitrogen		Total phosphorus	
		Pre-development 1800	Post-development 1975	Pre-development 1800	Post-development 1975	Pre-development 1800	Post-development 1975	Pre-development 1800	Post-development 1975
Alameda (Bayside)									
Berkeley	B	25	513	4,920	4,522	7	81	1	11
Lake Merritt	B	35	718	7,049	6,428	11	113	1	15
San Leandro	B	28	302	5,588	5,082	8	73	1	10
Hayward	B	113	651	22,651	21,871	35	161	3	21
Lower Alameda Cr.	B	46	108	9,260	9,039	15	28	0	3
Fremont	B	61	254	12,064	11,735	18	64	1	7
Alameda (Upper Alameda Creek)									
Calaveras (U.A.Cr.)	B	0	0	0	0	0	0	0	0
Upper Alameda Cr.	B	50	51	10,099	10,100	15	15	1	1
Arroyo Valle (U.A.Cr.)	B	0	0	0	0	0	0	0	0
San Antonio (U.A.Cr.)	B	0	0	0	0	0	0	0	0
DeLa Laguna	B	202	228	40,360	40,311	61	67	5	6
Pleasanton	B	25	96	5,000	4,849	8	24	0	3
Livermore	B	23	110	4,545	4,189	8	27	0	3
Las Positas	B	7	12	1,442	1,420	2	3	0	0
Dublin	B	11	58	2,226	2,157	3	15	0	2
Subtotals, Alameda		626	3,101	124,150	121,703	191	671	13	82
Contra Costa									
Marsh Creek	D	107	121	21,416	21,381	32	35	3	3
Kellog	D	56	57	11,157	11,153	17	17	1	1
Walnut Creek	B	155	789	30,948	29,978	46	192	3	23
Diablo	B	46	77	9,167	9,098	13	21	1	3
Alhambra	B	31	109	6,067	5,996	9	28	0	3
San Pablo	B	32	199	6,508	6,245	9	48	0	6
Pinole	B	49	120	9,698	9,598	14	31	1	4
Antioch	B	24	88	4,777	4,696	8	22	0	2
West Pittsburgh	B	34	161	6,790	6,659	10	40	1	5
Upper San Leandro	B	45	148	9,095	9,004	14	38	1	4
Richmond	B	29	477	5,029	4,767	8	75	1	10
Delta Lowland	D	57	64	11,438	11,423	17	17	1	2
Subtotals, Contra Costa		665	2,410	132,090	129,998	197	566	13	66
Marin									
Richardson Bay	B	50	327	9,972	9,519	15	74	1	8
Corte Madera Cr.	B	77	505	15,368	14,606	23	119	2	14
San Rafael	B	91	547	18,189	17,392	27	127	2	[illegible]
Novato	B	72	248	14,459	14,441	22	61	2	7
San Antonio Cr.	B	27	49	5,417	5,380	8	13	1	1
Lagunitas Cr.	O	149	195	29,920	29,730	44	55	4	5
Tomales Bay	O	195	214	39,068	38,999	58	63	5	6
Point Reyes	O	142	143	28,424	28,419	43	43	4	4
Bolinas-Stinson	O	79	100	15,838	15,755	24	29	2	3
Subtotals, Marin		882	2,328	176,655	174,241	264	584	23	62

Table 5-3. (Concluded)

County and major watershed	Discharge location[b]	Average annual discharge loading, 1000s lb[a]							
		BOD		SS		Total nitrogen		Total phosphorus	
		Pre-development 1800	Post-development 1975	Pre-development 1800	Post-development 1975	Pre-development 1800	Post-development 1975	Pre-development 1800	Post-development 1975
Napa									
Upper Napa River	B	235	298	44,581	42,378	67	96	5	9
Middle Napa River	B	374	707	74,928	69,082	112	219	10	21
American Canyon	B	102	123	20,479	17,071	31	58	3	5
Wooden Valley	B	78	79	15,445	14,654	24	27	2	2
Subtotals, Napa		789	1,505	155,433	143,185	234	400	20	37
Santa Clara									
Palo Alto-Mtn. View	B	115	547	23,045	22,676	34	132	3	17
Santa Clara, et al.	B	57	510	11,455	10,813	17	124	1	16
San Jose southwest	B	109	877	20,508	19,340	31	194	2	25
Coyote-Silver	B	153	495	30,580	29,979	47	126	4	15
Llagas-Uvas	O	177	251	35,489	35,406	53	70	4	7
Pacheco	O	145	146	28,925	28,927	43	44	4	4
Subtotals, Santa Clara		756	2,826	150,002	147,141	225	690	18	84
San Francisco									
San Francisco S.E.	B	16	2,124	3,143	3,968	5	119	0	16
San Francisco N.Pt.	B	10	1,383	2,052	2,583	3	78	0	11
San Francisco N.Shr.	B	5	660	1,099	1,232	2	38	0	5
San Francisco R-S	O	20	2,169	3,944	4,051	6	118	0	15
Subtotals, San Francisco		51	6,336	10,238	11,834	16	353	0	47
San Mateo									
Pacifica	O	29	136	5,755	5,222	9	33	1	4
Brisbane	B	8	50	1,687	1,610	3	12	0	2
So.San Francisco	B	25	242	4,983	4,844	7	55	1	7
Millbrae-Burlingame	B	26	334	5,118	4,618	8	77	1	10
San Mateo Creek	B	87	256	17,438	16,936	26	64	2	7
Belmont-Atherton	B	59	514	11,703	10,739	18	120	1	15
San Francisquito	B	66	390	13,269	12,293	20	94	1	10
Pescadero Creek	O	313	331	62,560	62,510	94	98	8	8
Half Moon Bay	O	123	198	24,661	24,560	37	54	3	6
Subtotals, San Mateo		736	2,451	147,174	143,332	132	607	18	69
Solano									
Vallejo-Benicia	B	72	272	14,387	14,129	21	69	2	9
Fairfield-Suisun	B	140	278	27,977	27,820	42	75	3	8
Collinsville	B	132	134	26,428	26,428	40	40	3	3
Subtotals, Solano		344	684	68,792	68,377	103	184	8	20
Sonoma									
Glen Ellen	B	121	157	24,338	24,290	36	45	3	4
Sonoma	B	105	219	20,837	20,706	32	58	2	6
Bayside	B	68	89	13,683	13,659	21	25	2	2
Penngrove	B	48	85	9,620	9,562	15	23	1	2
Petaluma Valley	B	51	176	10,130	10,010	15	44	1	5
Petaluma River	B	73	78	14,490	14,486	22	23	2	2
San Antonio Marin	B	36	38	7,042	7,038	11	11	0	1
Subtotals, Sonoma		502	842	100,141	99,751	152	229	11	22

a. 1969-1970 and 1970-1971 water years only.
b. B = Bay, D = Delta, O = Ocean.

FIGURE 5-2. REGIONAL LOADING DISTRIBUTION - BOD

Table 5-4. SURFACE RUNOFF LOADINGS TO BAY, PRE- AND POST-DEVELOPMENT

Parameter	Average annual loading[a], 1000s lb 1800	1975	Increase
Total BOD	3,190	18,590	5.8:1
Total SS	790,091	765,982	0.97:1
Total Nitrogen	1,193	3,677	3.1:1
Total Phosphorus	89	428	4.8:1

a. From values in Table 5-3, 1969-1970 and 1970-1971 water years only.

The increased ratios between 1800 and 1975 are most affected by the type of system, the intensity of development, and the amount of undeveloped land or buffer area. On a county basis for BOD, San Francisco expectedly showed the highest ratio, 124:1, and Sonoma the lowest, 1.7:1. Subregional hot spots other than San Francisco include Berkeley, Lake Merritt, and San Leandro watersheds in Alameda County, 17.4:1; Richmond in Contra Costa County, 16.4:1; Millbrae-Burlingame in San Mateo County, 12.8:1; and Santa Clara *et al*. and San Jose Southwest in Santa Clara County, 8.4:1.

Bay Impact Example

As described in Section 4, the recalculated loadings, for what may be representative of a once in 2-year storm, were applied to the San Francisco Bay simulator by ABAG and three dimensional graphical output obtained. Representative results are shown in Figure 5-3. The tendency for concentrations to spike in high discharge, low circulation areas is evident with the greatest buildups experienced at the mouth of the Napa River, Richardsons Bay, and extreme South Bay. The impact zone movement with recovery may also be seen in the diminshed but broadened peaks on the second day after the storm.

SENSITIVITY OF SELECTED PARAMETERS

A final activity that was initiated under the surface runoff modeling program was to test the sensitivity of certain model parameters. The site specific calibration/ verification process provided a useful assessment of the relative sensitivity of SWMM's flow and quality predictions to various model parameters. Although the sensitivity of

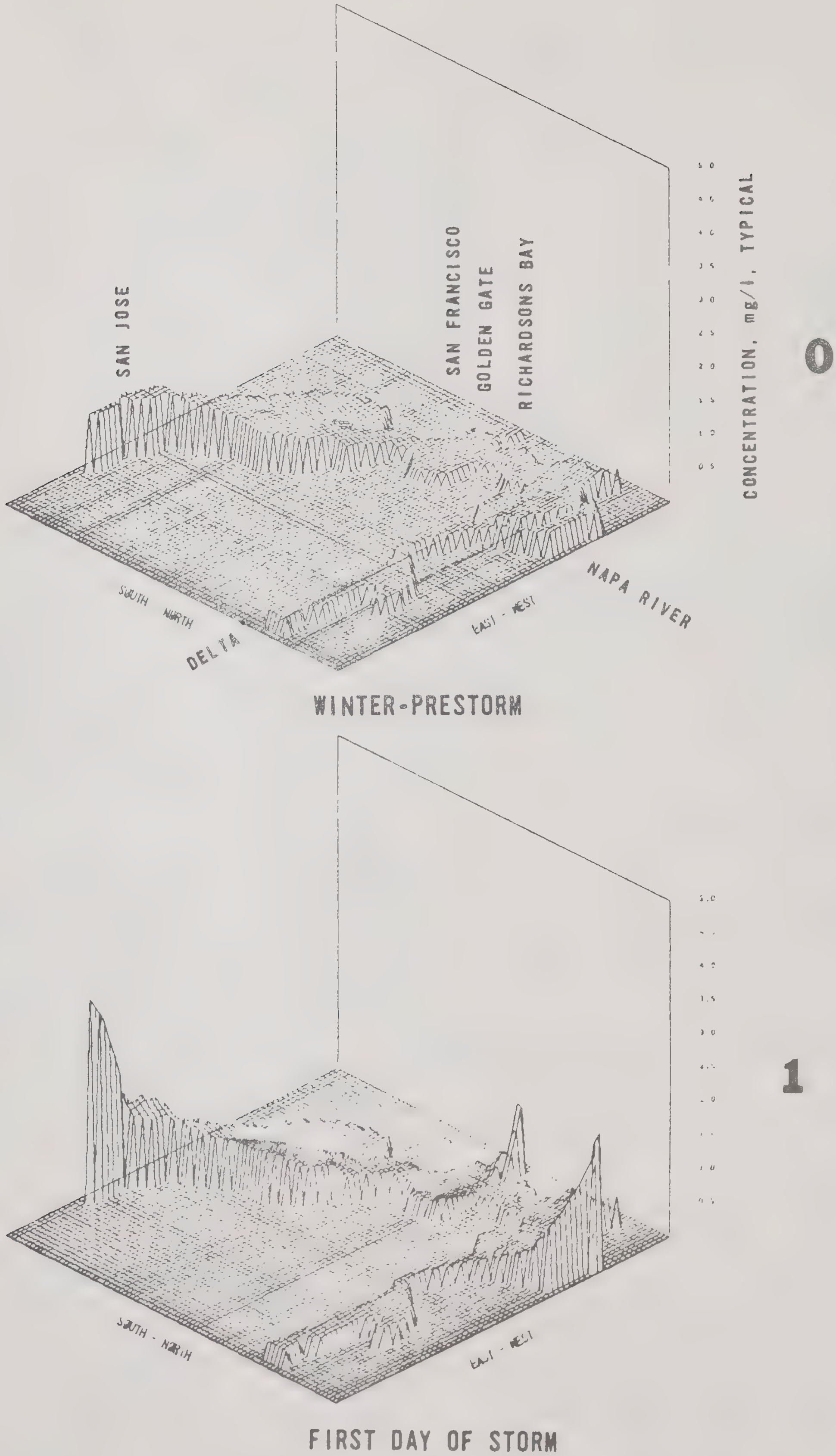
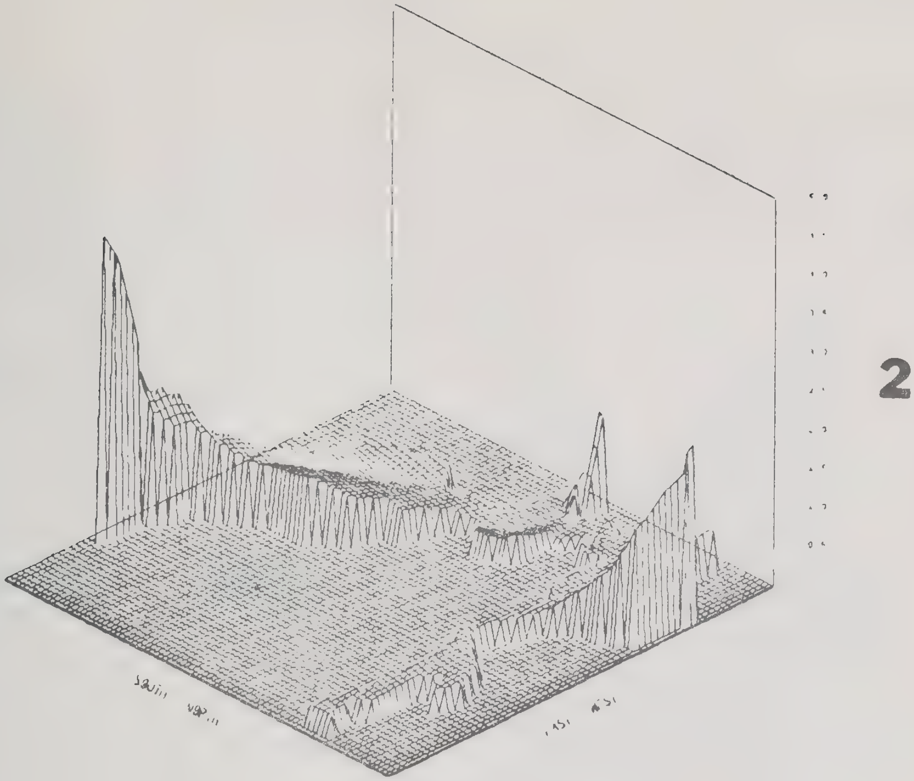
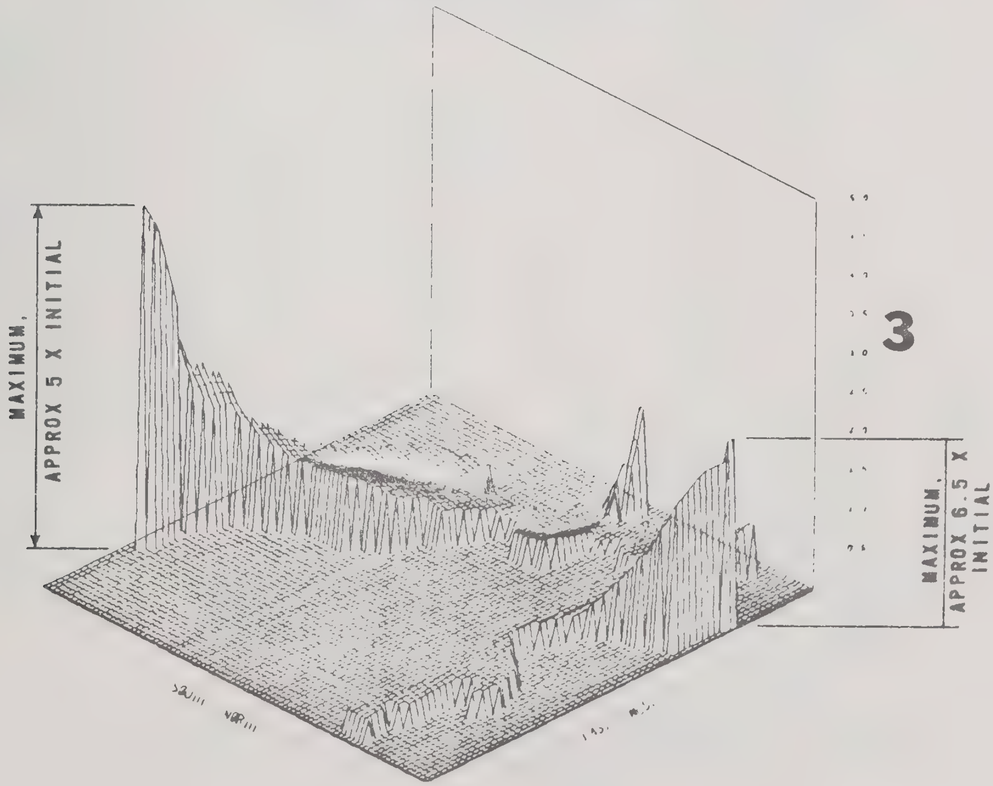


FIGURE 5-3. REPRESENTATIVE STORM IMPACTS ON BAY-BOD

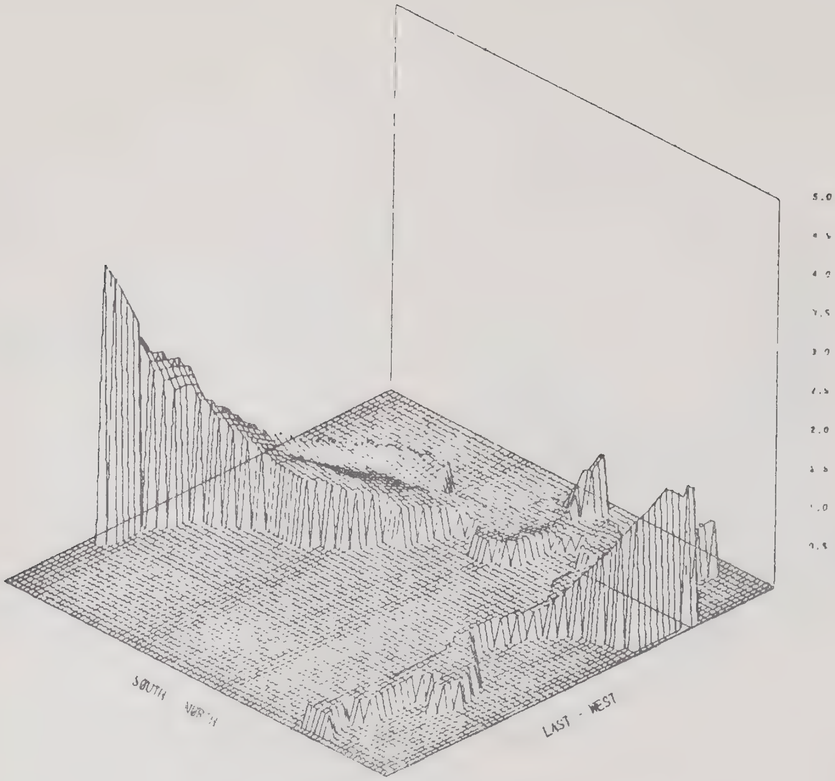


SECOND DAY OF STORM



THIRD (FINAL) DAY OF STORM

FIGURE 5-3. (CONTINUED)



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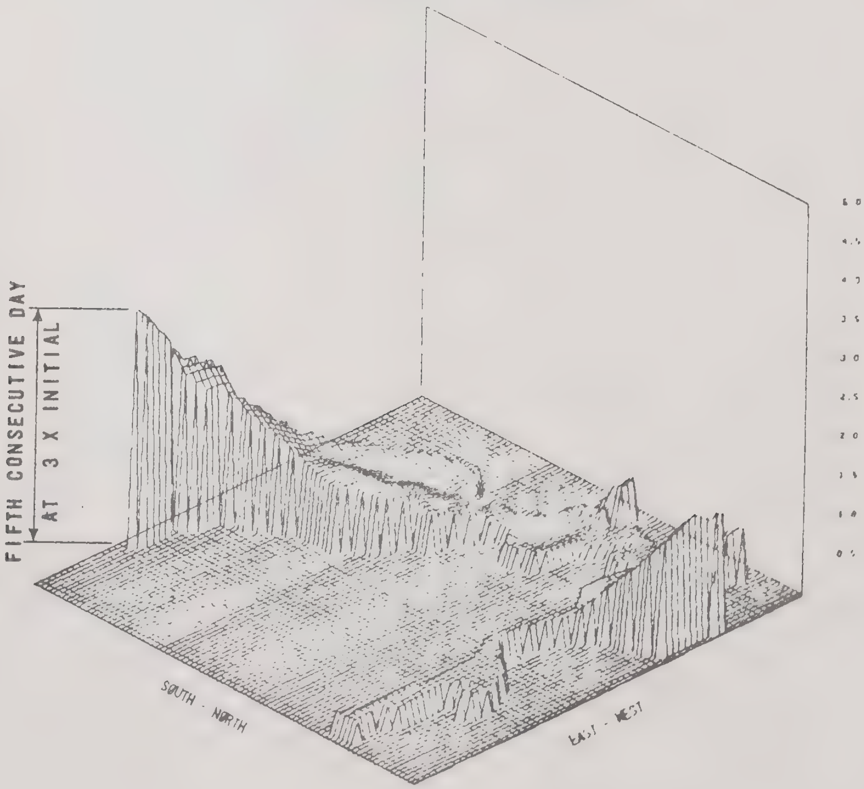
FIRST DAY AFTER STORM



5

SECOND DAY AFTER STORM

FIGURE 5-3. (CONCLUDED)

any given SWMM parameter is strongly dependent on watershed and storm characteristics, some useful generalizations were made. The sensitivity of important model parameters and recommendations which can be used as a rough guide in future applications are shown in Table 5-5. The table indicates that the most important parameters are:

- Infiltration rate and imperviousness (flow)
- Dust and dirt factor and curb length (urban quality)
- Soil erosion factor (rural sediment and quality)

Table 5-5. SUMMARY OF SWMM SENSITIVITY ANALYSIS

Parameter	Sensitivity	Recommendations
Imperviousness	Important influence on flow in smaller developed watersheds, less important in rural watersheds.	Should be adjusted during calibration if the watershed is developed and sufficient flow data are available.
Detention depths	Can have a significant adverse impact on flow if overestimated.	Safest procedure is to use smallest reasonable value for detention depths.
Overland Manning coefficients	Relatively unimportant coefficient.	Need not be calibrated unless model exhibits consistent problems in predicting time of flow peaks.
Infiltration rate	Generally the most important single parameter affecting flow. Highly dependent on antecedent soil moisture conditions.	Should be adjusted during calibration.
Subcatchment and slope width	Relatively unimportant as long as values are reasonable.	Generally need not be calibrated.
Channel length, slope, width, and Manning coefficient	Together these coefficients have a significant effect on flow peak timing but no single coefficient dominates.	Length and Manning coefficient should probably be varied during calibration since they are the most uncertain coefficients.
Percentage of area with zero detention	Generally unimportant unless the value becomes very large.	Comments for detention depths apply.
Dust and dirt (D&D) factor	Generally the most important single parameter affecting urban runoff quality (all constituents).	Definitely should be adjusted during calibration if quality data are available.
Suspended solids, BOD, and nitrogen, fractions of D&D	Not as important as the dust and dirt factor and curb length.	Generally not worth calibrating unless a large number of quality measurements are available.
Curb length	The values used for this parameter have a significant impact on both the magnitude and timing of the pollutographs for all constituents. Nearly as important as the dust and dirt factor.	Should be adjusted during calibration if quality data are available.
Soil erosion factor (K)	Predicted rural erosion is directly dependent on this parameter. Comparable in importance to the dust and dirt factor.	Should be adjusted during calibration if rural quality or sediment data are available.

The sensitivity of parameters in the MAC simulations are also very watershed sensitive because of the land use makeup and rainfall characteristics. However, if the entire region is lumped into a single watershed and uniform rainfall and watershed characteristics are assumed, certain relationships are easily calculated. For example, by drawing the gross land use characteristics from the study area totals in Table 4-2, the runoff coefficients from Table 4-6, and the quality coefficients from Table 4-15, the effective weighting regionwide of each parameter can be determined. The same type of breakdowns can, of course, be made subregionally with an expected improvement in accuracy because the uniformity assumption would likely be more applicable. Further subdivisions would eventually lead us back to the original subareas.

As an illustration of the regionally lumped system, assume the sensitivity of the BOD assumption for open areas is of greatest interest. The calculation proceeds as follows:

Land use	% of total area (1)	Runoff coefficient (2)	BOD concentration, mg/L (3)	Product (1x2x3)
Residential	9	0.3	15	40.5
Commercial	2	0.7	20	28.0
Industrial	2	0.6	13	15.6
Open	87	0.2	2	34.8
Total	100	--	--	118.9

Thus, in this simplification, the open areas are contributing (34.8/118.9) x 100 = 29.3% of the total BOD load. If the open area BOD concentration were underestimated by a factor of 2 but the runoff factor was overestimated by 2, the net BOD contribution would not change. If, on the other hand, all parameters were found to be correct except the open space BOD concentration, which was found to increase to 4 mg/L, the corrected open area contribution would be [(34.8 + 34.8)/(118.9 + 34.8)] x 100 = 45.3%. By comparison, the industrial coefficients (because they make up such a small percentage of the total area) are far less sensitive. Under the original assumptions, industrial areas would produce (15.6/118.9) x 100 = 13.1% of the total load and if underestimated in concentration by 100%, the corrected contribution would be [(15.6 + 15.6)/(118.9 + 15.6)] x 100 = 23.2%.

Because MAC is a simple model, the most practical way to test parameter sensitivities will generally be to make successive runs while varying the test parameter(s) over its (their) range of possibilities. The feasibility of making such analyses will largely depend on data introduced through the continuing programs, the subject of the next and final section.

Section 6

CONCLUSIONS AND RECOMMENDATIONS WITH RESPECT TO CONTINUING PROGRAMS

Surface runoff loadings to San Francisco Bay and its tributaries vary spatially, just as rainfall, land use, and type and age of stormwater and wastewater collection systems vary across the region. Surface runoff loadings vary temporally with rainfall and may be expected to be greater following prolonged dry periods (although this could not be confirmed by actual observations during the drought period of analysis).

Surface runoff models provide a useful tool in estimating and projecting loadings under varying growth plans and mitigation strategies. Models, however, do not make decisions but merely provide information derived from what they have received in a form more suitable for evaluation and which will aid the decision process.

Monitoring, carried out by the County lead agencies and coordinated by ABAG, has shown close correspondence between those concentrations found in Bay Area runoff and those accepted as national averages and ranges. However, since all monitoring was necessarily concentrated in the second year (1977) of the most severe 2-year drought in California history, major deficiencies could not be avoided and must be addressed in continuing programs. Of the subareas monitored, observations from Glen Echo, Alameda County, are about twice the norm and the lower Guadalupe River, Santa Clara County, about 1.5 times the norm. These differences are believed significant and are reflective of the older systems in the tributary areas. Common values (BOD) from the combined system of San Francisco, however, are about twice those of Glen Echo. The above coupled with receiving water sensitivities may be useful in setting priorities for remedial activities on a regional basis.

Perhaps the overriding weakness in the initial phase program has been in the lack of specifics with respect to adverse receiving water impacts and the demonstration that certain remedial actions, whether undertaken voluntarily or through regulatory permit procedures, would significantly reduce such impacts. This may be an inherited weakness from the initial national 208 program as a whole which attempts to set regional direction without first establishing its case on a "demonstration watershed" level where controls and impacts are much more easily and clearly related.

The following recommendations are offered for consideration in continuing planning programs:

1. Continue and expand systematic regional monitoring and reporting of surface runoff. It is only through programs such as these that attention can be continually focused on what may be a significant pollution problem, but also a problem which may be more related to system abuses or neglect than a necessity of urban and suburban life style.

2. Initiate programs of regionally directed receiving water monitoring specifically addressed to wet-weather discharges and impacts. A problem which cannot be seen or understood is unlikely to be corrected cost-effectively.

3. Continue to develop and apply mathematical models to aid in evaluation of remedial measures and also to identify the most pressing data needs.

4. Develop and support subregional demonstration projects which illustrate convincingly cause-effect relationships, isolate specific problems, and quantify results of remedial solutions.

5. Develop and publish an annual or biennial regional report on projects undertaken, results monitored, conclusions drawn, activities planned, and costs expended.

Hopefully, all parties participating in the initial ABAG Surface Runoff Management program would continue to be actively involved in, contribute to, and in turn, benefit by such a program.

It is obvious that the present state of knowledge of surface runoff management in the Bay Area is limited and must be actively developed if any significant water quality management strides are to be taken. The ABAG Surface Runoff Management program has built up a cadre of trained and concerned specialists through which continuing programs can, and should, be successfully implemented.

APPENDIX A

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Workshop Memorandum

Candidate Measures for the Control of Urban Runoff

for

Association of Bay Area Governments
Surface Runoff Management Plan

June 1977

60249A

Woodward-Clyde Consultants
Three Embarcadero Center, Suite 700, San Francisco, CA 94111

This workshop memorandum was prepared jointly by Woodward-Clyde Consultants and the ABAG staff. Its purpose is to assist the Bay Area counties, consultants, and others who are developing runoff management plans. The memorandum summarizes information on a broad variety of candidate control measures and is intended to serve as a framework to which the user will add other information. Note that the numbering system for the candidate control measures is structured to follow earlier outputs from ABAG.

CONTENTS

CONTROL MEASURE:	OBJECTIVE:
A-1 Implement street flushing	Reduce accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This control measure consists of flushing the streets with high-velocity low-volume sprays of water. The sprays would move surface contaminants along and/or across the street to the gutter and/or a storm sewer or catchbasin inlet. The transported material would then be collected from the point of accumulation and subsequently treated or disposed of. In systems with combined sewers, the flushed materials would be transported down to the treatment plant. The removed materials would not be available to become incorporated into the surface runoff at the time of a subsequent storm, thereby yielding less of an adverse effect on receiving waters.

It is assumed that the water used for flushing would be some type of reclaimed wastewater (e.g., disinfected secondary treated sewage, industrial wastewater, agricultural drainage, impounded surface runoff) rather than potable water.

APPLICABILITY

The measure would work best in areas with relatively sound, smooth street surfaces and sufficient topographic relief to assure good drainage toward the intended area of accumulation. It may be more effective than conventional street cleaning in areas where it is not possible to control on-street auto parking. Street flushing operations would be most effective in areas where curbs and gutters have been specially designed to intercept, trap, and channel the debris and flush water. A program of building such curbs and gutters (either new construction or retrofitting existing systems) would be particularly applicable to commercial or other areas where traffic and parked vehicles restrict the effectiveness of conventional street cleaning.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Flushing could substitute for conventional street cleaning activities, since it would be relatively effective at removing litter, dust, and dirt. In some areas, it might be used in conjunction with conventional street cleaning. Flushing equipment could also be used in the control of spills of certain types of materials onto streets and other paved surfaces.

IMPLEMENTATION REQUIREMENTS

Technical aspects

Required hardware would include a tank truck equipped with a pump and cab-controlled, high-velocity, low-volume spray-bars and nozzles. Support requirements would include a coordinated pickup program (e.g., vacuum eductor, street sweeper, broom crew*), maintenance parts and facilities, fuel, and a water supply.

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*This might not be necessary in some areas with combined sewer systems.

Administrative requirements

The flushing program would have to be carefully designed, approved, financed, and implemented. Approval would require resolution of issues related to the aesthetic and public health consideration of using wastewater in public places. T overall program would place demands on administrative and public works staff at al levels.

Legal/political considerations

The public health aspects of wastewater reuse could lead to legal/political problems. There could be water rights problems stemming from the need to transfer water among different designated watersheds. The most likely agencies to be invol with street flushing would be city or county public works departments. In additio several types of special districts are empowered for this purpose, including count service areas, community services districts, municipal improvement districts, maintenance districts, permanent road divisions, road maintenance districts, sanitary districts, and bridge and highway districts. Private arrangements among residents and nonprofit corporations are also potential institutional mechanisms for this purpose. This control measure requires that cooperative arrangements for access t water be established with such agencies as the city and county, or special distric

POTENTIAL IMPACTS

Environmental impacts

Use of the flusher trucks and associated pickup systems would contribute to traffic congestion, generate noise and air pollutants, and consume fuel. The litt and contaminants collected from the street surface would place a demand on the rema ing capacity of solid waste disposal sites.

Socioeconomic impacts

The flushed streets may be more slippery for a short period, thereby constitut ing a safety hazard. There may be some real or imagined adverse aesthetic effects associated with the use of reclaimed wastewater.

The flushing program would create a variety of employment opportunities at the administrative, operational, and maintenance levels. Special attention would have to be directed toward assuring that the flush water would not contribute to public health problems.

COST CONSIDERATIONS

Capital costs	$15,000 to 20,000 per flusher truck. Also it would be necessary to provide a system for supplying the flusher trucks with water (presumably reclaimed wastewater).

aintenance costs For flusher trucks:

major repairs	$ .35 per curb mile	
minor repairs	.25	
prevent. maint.	.13	
flusher system	.15	
	$ .88 per curb mile	

tal program costs* $20 per ton of material flushed off
$18 per cubic yard of material flushed off

ALUATION

rtion of the overall problem this measure would affect
Flushers can only deal with contaminants which reside on paved surfaces -- imarily streets and parking lots. These contribute a significant fraction of the tal suspended solids, BOD, and toxic materials in urban runoff.

tential effectiveness on affected portion
Flushers might be on the order of 60-90% effective in removing the materials of imary concern.

ticipated effectiveness in actual practice
At present, there is insufficient experience with the above-described high- essure, low-volume flushers and pickup systems (as they would apply to typical ban areas) to predict actual effectiveness.

AMPLES

Some Bay Area communities currently use nozzle-equipped tank trucks for a riety of flushing operations (e.g., Oakland, Hayward, San Francisco). These are specially designed, high-velocity, low-volume, pumped units. Nor are they used conjunction with pickup programs to remove the flushed materials from the system tirely.

Flushers of the type described here have been developed and found to be effec- e for decontaminating areas covered with fine dust and sand-like radioactive llout materials.

ERENCES

t, R., Ugelow, J., and Sartor, J. Systems Analysis of Street Cleaning Techniques. Woodward-Clyde Consultants, for APWA and NSF (March 1976).

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e cost of flushing has to be combined with the cost of somehow collecting the ushed material, except in systems with combined sewers.

Sartor, J., Boyd, G., 1972. Water Pollution Aspects of Street Surface Contaminants. EPA-R2-72-081.

Clark and Cobbin, 1964. Removal of Simulated Fallout from Pavements by Street Flushers. U.S. Naval Radiological Defense Laboratory, San Francisco.

CONTROL MEASURE:	OBJECTIVE:
A-2 Improve street sweeping	Reduce accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This measure involves the use of conventional street sweepers or vacuum units to clean street surfaces. It would consist of vacuuming, blowing, or sweeping (either manually or mechanically) litter and particulates up into a collection container for removal to a disposal site.

The removed materials would not be available to become incorporated into the surface runoff during a subsequent storm, thereby yielding a less adverse effect on receiving waters.

The term "improve street sweeping" refers to making better use of existing equipment (e.g., training operators, adjusting equipment to focus on collecting materials of dust and dirt size, increasing sweeping frequency, concentrating efforts where the most contaminants accumulate), obtaining new, more efficient equipment (vacuum units), and controlling vehicle parking (to maximize access to the dirty gutter areas).

APPLICABILITY

The measure is most applicable in urbanized (e.g., residential, commercial, and industrial) areas or other areas which have high loading intensities.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Street sweeping has as its primary benefits the improvement of aesthetic, health, and safety aspects of streets. The benefits of street cleaning programs are so great and so varied that the decision whether or not to implement such controls should consider all benefits to both the public and private sectors (and not just the water quality benefits).

IMPLEMENTATION REQUIREMENTS

Technical aspects

Required hardware would include mechanical sweepers and/or vacuum sweepers. Support requirements would include a coordinated pickup program to haul material to a disposal site, maintenance parts and facilities, and fuel. Some systems require water for dust control during the sweeping operation.

Administrative requirements

This program would have to be designed, approved, financed, and implemented. It would place demands on administrative and public works staff at all levels.

Legal/political considerations

The agency involved in street cleaning is usually the city or county public works department. In addition, several types of special districts are empowered for this purpose, including county service areas, community services districts, municipal improvement districts, maintenance districts, permanent road divisions, road maintenance districts, sanitary districts, and bridge and highway districts. Private arrangements among residents and non-profit corporations are also institutional mechanisms for this purpose.

Fiscal considerations

This technique is typically considered to be a local responsibility; as such, there are no state or Federal subsidies (with the possible exception of community development block grant money from the Federal Department of Housing and Urban Development or public works development money from the Economic Development Administration). General budget expenditures from local government are generally used. Where state or Federal highways pass through an area, CalTrans often makes funds available to local public works departments to sweep the highways. These funds are sometimes sufficient to partly subsidize the sweeping of local streets.

POTENTIAL IMPACTS

Environmental impacts

Street sweepers contribute to traffic congestion and generate noise and air pollutants. They typically create noise levels of 70 to 82 dBA at 50 feet (on a flat grade) during normal operation. Improved street sweeping program would generate additional solid wastes which would shorten the lives of solid waste disposal sites.

Socioeconomic impacts

Street cleaning operations tend to be labor-intensive and would create employment opportunities at the administrative, operations, and maintenance levels.

COST CONSIDERATIONS

Capital costs

3-wheel mechanical:	$23,000 to 33,000 per sweeper
4-wheel mechanical:	35,000 to 45,000 per sweeper
vacuum sweepers:	38,000 to 50,000 per sweeper

Mechanical costs

For conventional street sweepers:

major repairs	$ .44 per curb mile
minor repairs	.31
prevent. maint.	.41
brooms	.57
chains & sprockets	.22
other mounted systems	.32
Total	$2.00 per curb mile

Total program costs

$16 per cu yd of material collected
$18 per ton of material collected
$4 to 5 per curb mile (total program including labor)

Example: San Jose sweeps 25 miles per day and their sweeping program costs $125 per day ($5 per curb mile). Gasoline costs vary too widely to give a meaningful cost estimate. Each sweeper requires one operator.

EVALUATION

Portion of the overall problem this measure would affect

Street sweepers can only deal with contaminants which reside on paved surfaces -- primarily streets and parking lots. These are thought to contribute a major portion of the total suspended solids, BOD, and toxic materials in urban runoff.

Potential effectiveness on affected portion

An example of removal efficiencies for a mechanical sweeper making one pass over a street (with a loading intensity of 180 to 1800 lb/curb mile of total solids) is as follows: 54% removal of total solids, 40% of the BOD, 40% of Kjeldahl nitrogen, 20% of phosphate, 40% of pesticides, and 28% to 49% of various heavy metals. Vacuum sweepers are thought to be considerably more effective (up to 90%) on loose, fine materials.

Anticipated effectiveness in actual practice

In actual practice, street sweeping equipment typically removes 30 to 55% of the total solids, 25-40% of the BOD, 25 to 40% of the Kjeldahl nitrogen, 8 to 20% of the phosphate, and 25-65% of the heavy metals.

EXAMPLES

Virtually all Bay Area cities and counties are currently engaged in conventional street sweeping operations. Some cities have begun to reconsider their programs and equipment to focus on improving the collection of fine materials which tend to accumulate in gutters. This, taken together with the adoption and enforcement of auto parking regulations, will yield significant improvements. There is also some active interest in implementing some of the more modern vacuum sweepers because of their higher effectiveness on fine particle sizes.

REFERENCES

Sartor, J., Boyd, G., Van Horn, W. 1971. Cost-Effectiveness of Street Sweeping. URS Research Company for 1971 Public Works Congress and Equipment Show. Philadelphia, PA. September 11-16, 1971. 29 pp.

Pitt, R., Ugelow, J., Sartor, J. 1976. Systems Analysis of Street Cleaning Techniques. Woodward-Clyde Consultants for APWA and NSF.

Sartor, J., Boyd, G. 1972. Water Pollution Aspects of Street Surface Contaminants. EPA-R2-72-081. 237 pp.

CONTROL MEASURE:	OBJECTIVE:
A-3 Repair streets	Reduce generation and accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This measure consists of patching, repairing, or otherwise restoring street surfaces. It would include filling pot holes, sealing cracks, and applying such surface treatments as overlays, burner-overlays, chip seals, and seal coats. This would reduce the generation of pollutants in two ways. It would mechanically keep the street surfacing materials from decomposing and becoming part of the pollutants washed off during storms (note that asphalt and concrete pavements contribute to total solids loads and contain significant amounts of heavy metals: Pb, Hg, Cr, Cu, Ni, ZN, V). It would also fill, seal, or cover over areas which are eroding or collecting debris which later are washed off by surface runoff. If there were fewer holes and crevices within which such material could accumulate, it would be easier to attain higher sweeper and/or flusher efficiencies.

APPLICABILITY

This measure applies to all streets in disrepair. There is a correlation between loading intensities and the conditions of streets (e.g., streets in poor condition have the highest contaminant loads), however, it has not been determined that these facts are directly related in a cause-and-effect manner.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Street repair is usually initiated to maintain road safety, smooth riding conditions, dust control, and appearance. Water quality improvement would be an important side benefit which could come from only modest additional expenditures in these ongoing programs. Because the major benefits of the above control measure would be realized by other public works programs, the decision whether or not to implement the measure should consider overall benefits and costs — not just those related to water quality. Normally, the water quality benefits can be brought in as an additional form of justification in multiple-use projects (and hence improve the likelihood of approval and funding).

IMPLEMENTATION REQUIREMENTS

Technical aspects

A variety of street repair equipment is in common use, including rollers, heat planers, graders, overlayers, and key cutters. Large scale repairs are usually contracted out to commercial firms. Cities and counties typically have their own road crews to do small repairs. These crews require a variety of motorized and hand tools, vehicles to transport workers, gravel, asphalt and other patching materials. Fuel and maintenance for the vehicles would also be required.

Administrative requirements

Street repair programs must be designed, approved, financed, and implemented, thereby placing demands on administrative and public works staffs at all levels.

Legal/political considerations

The most likely agencies to be involved with street flushing would be city or county public works departments. In addition, several types of special districts are empowered for this purpose, including county service areas, community services districts, municipal improvement districts, maintenance districts, permanent road divisions, road maintenance districts, sanitary districts, and bridge and highway districts. Private arrangements among residents and nonprofit corporations are also potential institutional mechanisms for this purpose.

Fiscal considerations

Street repair is generally considered to be a local function, financed out of the local budgetary process of cities, counties, and special districts. State and Federal highway repair is the responsibility of the CalTrans. Federal subsidies for such public work programs are available under some circumstances.

POTENTIAL IMPACTS

Environmental impacts

Street repair operations contribute to traffic congestion, noise, and air pollutants. Heater-planers create additional air pollution emissions and heat. Heat shields should be employed to protect street trees. Material used for fill and patching during repairs and after repairs are effected should be covered while stored and subsequently cleaned up to prevent them from entering street runoff.

Socioeconomic impacts

This program would create employment for administrators, equipment operators, traffic controllers, planners, designers, and inspectors. Street repair could disrupt the flow of services and goods in the affected area. Citizens may complain if repairs are not quickly made.

EVALUATION

Portion of the overall problem this measure would affect

Street repair can control only a minor fraction of the total street contaminants, which contribute a major portion of the total suspended solids, BOD, and toxic materials, in urban runoff.

Potential effectiveness on affected portion

Specific values for street material loadings and that portion of street contaminants which remains in cracks and potholes after sweeping are unknown, and the measure's potential effectiveness cannot be addressed quantitatively at this time.

CONTROL MEASURE:	OBJECTIVE:
A-4 Control the use of certain chemicals	Reduce the accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This measure consists of limiting the use of certain chemicals (such as inorganic fertilizers, persistent insecticides, and herbicides) which may lead to adverse effects on aquatic ecosystems (and other aspects of the environment). This measure would discourage, regulate or possibly prohibit the use of such chemicals so that their residuals would not be incorporated into storm runoff.

APPLICABILITY

This control measure is widely applicable but would be difficult to apply on a local basis. The measure would probably be most effective if conducted on a regional basis and via a voluntary program directed by an effective public education campaign.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

The control of certain chemicals may be initiated for other reasons. For example, certain pesticides, paints, solvents, and aerosol propellants have come under control for other reasons (more may be controlled in the future). These actions have a secondary effect on urban runoff which is important but which probably could not have been achieved if the control of urban runoff quality were the sole reason for the controls.

IMPLEMENTATION REQUIREMENTS

Administrative requirements

The use of the potentially harmful materials referred to here could be controlled through public education programs, taxation, regulation, or outright prohibition through legislation.

Legal/political considerations

Local action to control chemicals usage may be pre-empted by the Federal "Toxic Substances Control Act." There would likely be a counter-campaign by the manufacturers or sellers of products subject to control.

POTENTIAL IMPACTS

Environmental impacts

Conversion to organic fertilizers could provide additional side benefits. If equally effective substitute products are not available, it may be difficult to control pests and nuisance plants.

Socioeconomic impacts

This control measure would adversely influence the manufacturers of these chemicals and could affect the associated jobs.

The cost of purchasing or applying some substitute chemicals may be higher than the regulated chemicals.

EVALUATION

Portion of the overall problem this measure would affect

The control measure affects only nutrients and persistent chemicals in runoff. The importance of these substances relative to the overall runoff problem would depend on situations in each specific county and cannot be summarized here in any meaningful way.

Potential effectiveness on affected portion

If all deleterious chemicals were banned, then this control measure would be 100% effective in controlling pollution from these chemicals.

Anticipated effectiveness in actual practice

It is unlikely that many such substances will be controlled in the near future. The practical effectiveness of this control measure would depend on the cost of substitute products, public education and enforcement programs, and the degree of opposition that manufacturers or sellers might mobilize.

EXAMPLES

San Mateo County plans to implement a program of public education on the use of potentially detrimental substances. Napa County controls agricultural chemicals through the County Agricultural Commissioner for safety and health. King County, Washington, has published a brochure which educates the public on the need for conscious application of a variety of substances which have potential adverse effects on receiving waters.

REFERENCES

U.S. House of Representatives. 1976. Legislative History of the Toxic Substances Control Act. Committee on Interstate and Foreign Commerce.

CONTROL MEASURE:	OBJECTIVE:
A-5 Control the use of lots	Reduce the accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This control measure consists of implementing small-scale land use controls applicable to lots and other relatively small parcels. In most communities there are empty lots which tend to have contaminated runoff due to such activities as illicit dumping, vehicle repair, weed control, dog littering.

This measure consists of using laws, ordinances, or special programs to control the use of lots. It could include public information programs, strategic placement of litter receptacles, and enforcement of ordinances. It might also include special programs to pick up wastes from private properties and public open spaces. This measure would help to reduce litter and organic wastes including BOD, phosphorus, and nitrogen.

The effectiveness of this measure could be enhanced by imposing fines or penalties on parties who violate planning commission orders or anti-litter laws.

APPLICABILITY

The measure would be most applicable in areas with relatively high population densities (such as residential and commercial areas).

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Measures to prevent the accumulation of litter, solid wastes, and plant materials have usually been implemented to improve aesthetic and health aspects. This measure would extend and enhance existing programs to also focus on localized land use and materials which contribute to runoff-related pollution.

IMPLEMENTATION REQUIREMENTS

This type of land use control program would have to be designed, approved, financed and implemented. There would be demands on administrative and public works staff in all phases.

POTENTIAL IMPACTS

At this stage of analysis, it is not possible to make meaningful predictions of the measure's environmental or socioeconomic impacts, its costs, or its effectiveness.

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*This control measure does not refer to parcels which have designated, formally sanctioned land uses, since these would be covered under conditional land use permits.

CONTROL MEASURE:	OBJECTIVE:
A-6 Control littering and solid waste practices	Reduce accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This measure consists of using laws, ordinances or special programs to control littering and solid waste practices. It could include aggressive public information programs, increased and more strategic placement of secured, covered litter receptacles, and strict enforcement of ordinances. It might also include special programs to pick up organic wastes from private properties and public open spaces (such as grass clippings, leaves, branches). This measure would help to reduce litter and organic wastes including BOD, phosphorus, and nitrogen.

The accumulation of pollutants prior to runoff could also be reduced by imposing fines or penalties on parties who violate anti-litter laws or by providing a public collection service for plant material and litter. Some control could also be achieved by restricting the sale of disposable bottles, cans, and other packaging materials.

A related aspect of this measure would be the control of materials which accidentally become litter (i.e., the spillage and other loss of solid waste materials from refuse containers, refuse collection vehicles, and other solid waste management activities). This would include the improved operation of all legitimate solid waste management activities, the information management of solid wastes (e.g., the householder who spills debris on the way to the local landfill), and intentional, illicit dumping of wastes in areas not designated as disposal sites.

APPLICABILITY

The measure would be most applicable in areas with a high population density (such as residential and commercial areas).

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Measures to prevent the accumulation of litter, solid wastes, and plant materials on streets, sidewalks, parks, and other areas have usually been implemented to improve aesthetic and health aspects. This measure would extend and enhance existing programs to also focus on the materials which contribute to runoff-related pollution.

IMPLEMENTATION REQUIREMENTS

Technical aspects

Additional waste receptacles and collection vehicles and crews may be necessary. A program to pick up leaves and other plant materials would require trucks, some hand tools, and crews. Support requirements would include maintenance parts, facilities, and fuel. Collected materials would increase demands on waste disposal operations.

Administrative requirements

The litter control program would have to be designed, approved, financed and implemented. There would be demands on administrative and public works staff in all phases.

Legal/political considerations

Litter control is currently handled by CalTrans, other state and local park agencies, and general purpose governments. Systems of incentives and fines have been established to discourage littering; however, improved enforcement appears to be necessary.

Each county has a Solid Waste Management Plan and an Environmental Management Plan which typically deal with litter and other solid wastes.

Fiscal considerations

Litter control is financed out of local government general revenues. Recycling has become increasingly cost effective in recent years.

POTENTIAL IMPACTS

Environmental impacts

Implementation of this measure would increase the load at solid waste disposal sites and would add to the demand for additional sites and improved waste disposal practices.

Socioeconomic impacts

Additional employment opportunities would be created at the administrative, maintenance, and regulatory levels.

COST CONSIDERATIONS

The state of Washington has distributed its litter control budget in the following way:

- 35% - grants to local agencies (for enforcement, youth programs)
- 30% - goods and services (e.g., litter bags, development of school curricula)
- 25% - salaries and wages of personnel administrating the litter control program
- 5% - fringe benefits to personnel
- 5% - travel and miscellaneous equipment costs

EVALUATION

Portion of the overall problem this measure would affect

This measure addresses litter in public places and, in addition, plant litter that would be collected from private properties. These materials contribute an unknown portion of the overall urban runoff pollution problem.

Potential effectiveness on affected portion

It is not possible to predict the effectiveness of future litter control programs.

Anticipated effectiveness in actual practice

Unless these programs were strictly enforced and carried out, it is likely that they would be only moderately effective. A considerable portion of the material found on sidewalks and eventually on streets and in gutters is litter or grass clippings. Waste receptacles in public places are often not adequately covered or properly secured (so that wind and animals disperse the litter on the street). Frequently individuals and groups will haul material to a disposal site leaving a trail of debris because it was not properly covered. Enforcement would be the key to an effective program.

EXAMPLES

Litter laws and ordinances are in existence on the state and local level. The State of Washington has enacted and implemented an extensive "Model Litter Act/Public Service Act." Detailed information on this program can be obtained by contacting the Department of Ecology.

Questionnaire inputs from Bay Area cities indicate that virtually all cities have some form of litter control program, most of which focus on providing litter receptacles in heavily-trafficked areas (e.g., downtown, shopping centers, schools, parks, bike paths). Collections are typically made on a weekly (or more frequent) basis, depending in part on season. Reported costs vary over a very broad range (probably more because of differences in accounting systems than actual effort expended).

REFERENCES

Sally J. Hicks. Administrative Assistant. Department of Ecology. Washington State Model Litter Control Act. Olympia, WA 98504.

CONTROL MEASURE:	OBJECTIVE:
A-7 Control contaminants from domestic animals	Reduce the accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This measure would encompass a variety of means by which the wastes from domestic animals could be prevented from entering runoff. The wastes from all animals (wild animals, livestock, pets) contribute contaminants such as BOD, algal nutrients, and enteric bacteria (of which coliforms are the usual indicator). It would be difficult to control pets and livestock (and virtually impossible to control wild animals), but some measures may be effective under certain circumstances. Leash laws could be passed and enforced to help control dogs in urban areas. Density regulations could be imposed in suburban and rural areas to avoid localized pollution of groundwater and surface runoff which could result from having too many animals on insufficient land areas. Manure piles and other areas of waste accumulation could also come under control.

APPLICABILITY

This measure would be most effective if focused in areas known to be major sources of animal wastes which coincide with areas where water quality problems have been identified.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This measure would provide benefits to (and should be coordinated with) other public programs directed toward public health, water supply, vector control, odor abatement, and land use planning. Because its benefits would accrue to a variety of programs, decisions over implementation should consider all costs and benefits — not just those relative to runoff water quality.

IMPLEMENTATION REQUIREMENTS

Administrative requirements

The following efforts would place demands on administrative staff: assessing the need for and potential effectiveness of such a control measure, establishing the necessary regulations, conducting a public information program, inspecting source areas, and areas known to have water quality problems.

Legal/political considerations

Most Bay Area communities could attain sufficient control through the enforcement of leash laws, zoning controls, and/or land use controls.

POTENTIAL IMPACTS

At this stage of analysis, it is not possible to make meaningful predictions of this measure's environmental or socioeconomic impacts, its costs, or its potential effectiveness.

CONTROL MEASURE:	OBJECTIVE:
A-8 Control the use of motor vehicles	Reduce the accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This measure would consist of implementing various means of restricting the use of automobiles, trucks, and other vehicles in areas where they contribute significant quantities of surface contaminants which lead to runoff pollution. It would have the effect of reducing contaminants related to combustion products, lubricants, clutch and brake linings, tracked-in soil, broken vehicle parts, and litter. The measures could be direct (e.g., specific bans of certain classes of vehicles from certain portions of the community) or indirect (e.g., displacement of the private vehicle through improved public transportation, reduced availability of downtown parking, increased parking fees). Water quality problems from vehicular pollutants may diminish somewhat over the coming years if the society makes a significant shift away from the use of automobiles. This could occur as a result of such things as annoying traffic conditions, fuel costs, commuter taxes, and/or land use controls directed toward air pollution control.

APPLICABILITY

Such measures would apply primarily to heavy traffic areas (e.g., central business districts, strip commercial areas, highways) or areas tributary to receiving water areas that are known to be adversely affected by urban runoff.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

It is unlikely that measures to control the use of motor vehicles would be implemented for the sole purpose of controlling water quality. Rather, the water quality benefits might be cited as additional justification for implementing measures for other purposes (e.g., traffic congestion, air quality, reduced maintenance programs).

IMPLEMENTATION REQUIREMENTS

Technical aspects

Implementation of vehicle controls could vary widely from providing signs, pavement markings, and/or physical barriers to displacing automobiles by means of alternative transportation modes (e.g., buses, encouragement of bicycles and "mopeds", "people movers", "moving sidewalks").

Administrative requirements

The demand for administrative efforts would depend heavily upon the nature of the measures by which vehicular control were accomplished. Specific knowledge of the control program would be required to make any meaningful estimate of the need for administrative effort.

Legal/political considerations

It is unlikely that there would ever be impetus to achieve the control of motor vehicle use, based solely on the argument that urban runoff quality would improve. However, if there are other legally and politically attractive arguments for some degree of control, the incremental benefits of water quality improvement could be cited as additional rationale.

POTENTIAL IMPACTS

The concept of controlling the use of motor vehicles is introduced here in the abstract. It is not possible to make meaningful predictions of what environmental or socioeconomic effects would result from the loss of the motor vehicle or its replacement.

EVALUATION

At this stage of analysis, it is not possible to make meaningful predictions as to how effective it would be to control the use of motor vehicles.

CONTROL MEASURE:	OBJECTIVE:
A-9 Control the direct discharge of pollutants into storm sewers	Reduce accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This measure consists of implementing regulations, ordinances and/or public information programs to prevent the direct dumping of pollutants into the storm sewers via catch basins, storm sewer inlets, direct sewer connections, or other structures. Such pollutants might include waste motor oil, solvents, paint, pesticides, detergents, and/or grass clippings.

The measure could be as simple as disseminating information to the public to discourage their discharging pollutants into the storm sewer system. The measure might involve imposing and enforcing fines or other penalites. Incentives to recycle some pollutant substances (e.g., used motor oil) or dispose of them at managed collection points or dump sites could also be effective. The overall intent would be to reduce the accumulation of pollutants in the sewer system prior to runoff.

APPLICABILITY

The measure is most applicable in areas where direct dumping is known to occur commonly, however, regulations would typically apply to an entire political unit.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Public programs to prevent mosquitos from breeding in catchbasins (or other portions of the drainage system) would probably be made exempt from this control measure.

IMPLEMENTATION REQUIREMENTS

Technical aspects

Most service stations have storage containers (and removal arrangements with reclamation companies) which could accommodate used oil from the public; therefore, implementation of programs would require administrative rather than technical efforts.

Administrative requirements

Public information programs, ordinances, or regulations would have to be designed, approved, financed and implemented. This measure would place demands on an administrator and staff. Arrangements would have to be made with regard to collection points (e.g., service stations, public works corporation yards, city waste disposal sites), proper containers, and recycling.

Legal/political considerations

There are regulations concerning the packaging, labeling, sale, and use of some potential pollutants, but there are few regulations that are directed toward the control of the direct dumping of chemicals and other materials into storm sewers once they are publicly available and properly labeled. Recycling programs for crankcase oil exist on an informal, unregulated basis.

Fiscal considerations

Given the virtual absence of such regulations and restrictions, there is no information available on financing aspects.

POTENTIAL IMPACTS

Environmental impacts

By prohibiting dumping contaminants into the storm sewer system, illicit dumping could simply switch to sanitary sewers, backyards, empty lots, and other places out of the public eye. This could result in adverse impacts on vegetation, groundwater quality, fire safety, and visual aesthetics.

Socioeconomic impacts

Employment opportunities would be created for administrators and staff, planners, and people in advertising (e.g., newspapers, radio, television, printers).

Additional costs might have to be borne by the consumer to dispose of pollutants by some means other than direct dumping into the storm sewers. There could be some increase in the demand on and opportunities for recycling centers and approved disposal sites (and could create related jobs). There would also be a need for inspectors and other enforcement personnel.

EVALUATION

Portion of the overall problem this measure would affect

This measure would affect a broad range of pollutants (e.g., BOD, phosphates, nitrogen, suspended solids, heavy metals). No specific information is available on the quantities of materials which enter the storm water by direct dumping.

Potential effectiveness on affected portion

No meaningful estimates can be made at this time.

Anticipated effectiveness in actual practice

Regulations to control such dumping would be difficult to enforce. Public information campaigns could be rather effective, since citizens tend to be unaware of both the quantity of pollutants that are involved and the nature of their impact.

CONTROL MEASURE:	OBJECTIVE:
A-10 Eliminate cross-connections with sanitary sewers	Reduce the pollutants carried by runoff

SUMMARY DESCRIPTION

This control measure consists of fully separating storm and sanitary sewers. It recognizes the fact that systems which are intended to be separate still have many points of cross-connection (some known but most illicit or unintentional). This measure would consist of determining where such cross-connections exist and physically separating the systems (via corrective construction), thereby preventing sanitary sewage from contaminating the storm runoff.

APPLICABILITY

Since most cross-connections in a community would be very difficult to identify and/or rectify under normal conditions, this measure is most applicable in situations where the existing sewers are to undergo significant maintenance (e.g., cleaning, regrouting, lining), modification, or replacement.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

The separation of storm and sanitary sewers (in systems intended to be separate) would provide benefits to a variety of public works and public health programs. For example, storm water would contain less pollutants, and there would be less likelihood of polluting groundwater in areas where storm sewers leak. Because many of the major benefits of eliminating cross-connections would be realized by other public programs, the decision whether or not to implement this measure should consider overall benefits and costs - not just those related to runoff water quality. These benefits could be presented as additional justification for proposed sewer maintenance or replacement projects (thereby improving the likelihood of approval and funding).

IMPLEMENTATION REQUIREMENTS

Technical aspects

In areas where storm sewers are to undergo significant maintenance, modification, or replacement, the identification and elimination of cross-connections would be relatively straight-forward. A program of searching for cross-connections would have to be implemented. There would also have to be some construction of legitimate new connections to the sanitary sewers. In some cases, this would be difficult and/or costly (this generally is what gave rise to the illicit connections). Construction and common sewerage supplies (e.g., pipe fittings, concrete, aggregate, suitable backfill, pavement) would be required.

Administrative requirements

In areas where storm sewers are to undergo significant changes (which would allow the identification of cross-connections), there could be a minor demand for additional public works department involvement (focused on identifying the connec-

tions, informing and/or citing the violators, and overseeing the necessary remedial construction). In areas where access to the storm sewers is adequate, it would be necessary to conduct investigations to locate important cross-connections. This could require considerably more public works staff effort but may still be an effective means of reducing runoff problems.

Legal/political considerations

Most agencies with authority and responsibilities related to storm sewer systems have a legal basis for restricting the nature of what can be discharged to their systems (all such Bay Area agencies specifically prohibit the discharge of sanitary wastes to separated storm sewers). In some cases, it may be necessary to amend local ordinances to make it clear that such prohibitions apply also to industrial wastes and a broad variety of other substances known to cause problems in urban runoff. In general, such regulations should be structured to place the burden of compliance on the discharger.

POTENTIAL IMPACTS

Environmental impacts

There would be no significant environmental or socioeconomic impacts resulting from disconnecting the sanitary drains form the storm sewers. This is largely because the act of separation would typically coincide with other major sewer construction activities. In cases where sanitary sewers do not exist, are inaccessible, or are already operating at capacity, there may be environmental and/or socioeconomic impacts associated with providing adequate waste transport, treatment, and disposal.

COST CONSIDERATIONS

No meaningful cost estimates can be made at this stage.

EVALUATION

At this stage of analysis, it is not possible to make meaningful predictions of how effective it would be to control cross-connections.

CONTROL MEASURE:	OBJECTIVE:
A-12 Clean catchbasins	Reduce the accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This control measure consists of removing the materials which collect in catchbasins.* Catchbasins typically accumulate a variety of materials, which, upon "storage" between storm events, tend to partially decompose. This makes them particularly objectionable contributors to urban runoff pollution. Some of these materials are debris which were removed from the surface runoff at some prior event through the catchbasin's action as a single sedimentation device. Some of the materials fell into the basin by chance or were transported there by wind or the action of passing vehicles. Some of the materials were intentionally dumped there (although most communities have ordinances intended to preclude such means of disposing of litter, refuse, grass cuttings, spent motor oil, etc.). This control measure recognizes that most catchbasins are not cleaned often enough for them to provide a net benefit in the runoff management system. By cleaning catchbasins periodically (e.g., just before and several times during the rainy season), the pollutants would not be available to become incorporated into the runoff.

APPLICABILITY

This measure could be used wherever there are catchbasins, but would be most effective in areas where experience has shown that catchbasins tend to accumulate solids rapidly and where those solids tend to contain relatively high proportions of organic matter or other deleterious substances. Areas in central business districts or of relatively low socioeconomic status have been found to accumulate materials rapidly (some suburbs also have problems with leaves and grass cuttings).

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Most Bay Area communities which have catchbasins already have cleaning programs, so this measure could represent only an incremental increase in an existing program. Most local programs clean catchbasins only on demand, averaging on the order of one cleaning per year. Where catchbasins are being cleaned regularly, the benefits to water quality could be considerable, compared to the relatively small incremental cost increase. The decision whether or not to implement this control measure should consider all benefits to both the public and private sectors (and not just the water quality benefits).

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*The term catchbasin, as used here, refers to an inlet to the storm sewer system which provides on the order of a cubic yard of volume in the form of a trap or sump, arranged such that the inflowing water is detained long enough to permit coarse, dense solids to settle out.

IMPLEMENTATION REQUIREMENTS

Technical aspects

The cleaning of catchbasins can be done by hand or by using simple mechanical "buckets" and a small truck-mounted boom, but most cities favor truck-mounted vacuum eductors. Additional required support would include hand tools, fuel and maintenance parts and facilities, and a disposal site for the collected material. The use of a second truck for hauling the material to the disposal site might be warranted in some applications.

Administrative requirements

An increase of catchbasin cleaning could place additional demand on administrative and public works staff.

Legal/political considerations

The agency involved in cleaning catchbasins is usually the city or county public works department. In addition, several types of special districts are empowered for this purpose, including county service areas, community services districts, municipal improvement districts, maintenance districts, permanent road divisions, road maintenance districts, and sanitary districts.

Fiscal considerations

This technique is typically considered to be a local responsibility; as such, there are no state or federal subsidies (with the possible exception of community development block grant money from the Federal Department of Housing and Urban Development or public works development money from the Economic Development Administration). General budget expenditures from local government are generally used.

POTENTIAL IMPACTS

Environmental impacts

Equipment and techniques used in cleaning catchbasins will contribute to traffic congestion and generator noise, odor, and air pollutants. Catchbasin cleaning programs would generate additional solid waste which would place additional demands on solid waste disposal operations (approximately one ton of material typically accumulates in each catchbasin).

Socioeconomic impacts

Catchbasin cleaning operations tend to be labor intensive and would create employment opportunities on a variety of levels.

COST CONSIDERATIONS

The cost of catchbasin cleaning equipment and programs have been estimated as follows:

Capital costs: $42,000 for educator

$400 - 1000 for catchbasin

Maintenance costs:

manual	$8/catchbasin	$15/cu. yd. of matl. collected
educator	$6/catchbasin	$ 4/cu. yd. of matl. collected
vacuum	$8/catchbasin	$ 9/cu. yd. of matl. collected

Typical cleaning frequencies: once per year

Recommended cleaning: just before rainy season

EVALUATION

Portion of the overall problem this measure would affect

This control measure can control only those materials which accumulate in catchbasins. Therefore it would not benefit areas which are unsewered or do not have catchbasins.

Potential effectiveness on affected portion

All of the material collected from the catchbasin would be prevented from contaminating runoff. However, catchbasins themselves are not particularly effective as pollution abatement devices because they tend to pass most fine materials and the associated pollutants (the removal efficiencies drop sharply when basins are approximately half full).

EXAMPLES

Most Bay Area cities and counties are currently engaged in some types of catchbasin cleaning operations. Some local cities have been reconsidering their programs and equipment to focus on improving the frequency of cleaning to collect materials which accumulate.

REFERENCES

Lager, J., Smith, W. 1976. Catchbasin Technology Overview and Assessment (Draft Report). EPA contract No. 68-03-0274.

CONTROL MEASURE:	OBJECTIVE:
A-13 Clean storm sewers and drainage channels	Reduce the accumulation of pollutants prior to flushing by runoff

SUMMARY DESCRIPTION

This control measure consists of cleaning storm sewers and drainage channels periodically to remove the deposits of pollutants which tend to accumulate there. These deposits of solids (which range in character from coarse debris and plant materials down to silt and sludge-like fines) contain very high concentrations of a broad range of pollutant substances. This control consists of taking action to physically remove such deposits so they would not be present to be flushed into receiving waters by storm runoff.

APPLICABILITY

This measure would be most applicable in situations where the size, location, and configuration of the sewer (or channel) permits ready access for the cleaning equipment. It would provide maximum benefit in those reaches where considerable quantities of solids tend to deposit (e.g., because of a nearby source, because of comparatively low flow velocities, or because of obstructions or unusual sewer or channel geometry). Areas with high street surface contaminant loadings (e.g., commercial and industrial areas), relatively flat sewer grades, and few (or infrequently cleaned) catchbasins would be the best places on which to focus. Periodic inspections (direct observation or via in-sewer TV) are generally the best guide for focusing cleaning efforts.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure would also yield important benefits to other public works programs (e.g., flood control, sewer maintenance and repair, stormwater treatment). Because many of the benefits would be realized by these other programs, the decision whether or not to implement the measure should consider overall benefits and costs — not just those related to water quality. Normally, the water quality benefits can be brought in as an additional form of justification in multiple-use projects (and hence improve the likelihood of approval and funding).

IMPLEMENTATION REQUIREMENTS

Technical aspects

Implementation of this measure would require the stratigically-timed deployment of hydraulic and/or mechanical cleaning systems and operating crews. Hydraulic cleaning typically requires a special truck equipped with high-pressure pump, hoses and nozzles, used in conjunction with a truck-mounted vacuum pickup system. Mechanical cleaning ranges from manual approaches to cable or rod actuated buckets. The approach used would vary significantly due to local conditions and the availability of crews and equipment. Since the purpose of this measure is to remove accumulated pollutants prior to their being flushed away by storm runoff, the best strategy would be to schedule the cleaning to occur just before the rainy season

(i.e., when the largest accumulations are available). Compromises would have to be made, since this would place unmanagable short-term demands on crews, equipment, and support facilities and supplies (e.g, spare parts, fuel, maintenance). Where flush water is required, it may be possible to use treated wastewater rather than potable water (depending upon the required haul distance).

Administrative requirements

A program to significantly increase sewer cleaning facilities would have to be designed and approved and would typically require additional public works personnel at all levels.

Legal/political considerations

The most likely agencies to be involved with such sewer cleaning activities would be city or county public works departments. In addition, several types of special districts are empowered for this purpose, including some county service areas, community services districts, municipal improvement districts, maintenance districts, and sanitary districts.

POTENTIAL IMPACTS

Environmental impacts

Use of the sewer maintenance trucks, flushers, and associated pickup systems would contribute to traffic congestion, generate noise, odors, and air pollutants, and consume fuel. The debris and contaminants collected from the sewers and drainage channels would place a demand on the remaining capacity of waste disposal operations.

Socioeconomic impacts

Implementation of substantially increased sewer and channel maintenance measures would yield employment opportunities in both the public and private sectors (e.g., engineering, public works operations, inspection, administration). Because the increase in labor and equipment requirements could be costly, this measure could be in competition for funds and personnel resources needed fcr other public programs.

COST CONSIDERATIONS

Reported sewer cleaning costs vary widely, depending primarily on the following factors: sewer size, conditions, access, surrounding land use, weather patterns, and type of cleaning approach used. Estimated costs tend to be on the order of $50 to 100 per cubic yard of material removed (depending upon the amount of deposits per unit length of sewer). The cost of cleaning open drainage channels vary too widely to summarize here, but depend on such factors as channel size, bottom type, vegetation, access, surrounding land use, weather patterns, and the degree to which there is a need to protect riparian biota from being disturbed.

EVALUATION

At this stage of analysis, it is not possible to predict the effectiveness that sewer or channel cleaning would have on water quality (except on a case-by-case basis). However, the principal researchers in the field of urban runoff control agree that this would be one of the most effective candidates available.

EXAMPLES

Most Bay Area communities have some sort of routine sewer cleaning program. Most of them are scheduled on a demand-responsive basis (i.e., cleaning is done when problems become evident); some are scheduled routinely, but none are conducted for the primary purpose of collecting accumulated deposits to prevent them from polluting receiving waters.

REFERENCES

Lager, J. and Smith, W. 1974. Urban Stormwater Management and Technology. EPA-670/2-74-040. 447 pp.

Tourbier, J. and Westmacott, R. 1974. Water Resources Protection Measures — A Handbook. Water Resources Center, Univ. of Delaware, Newark, Delaware. 237 pp.

CONTROL MEASURE:	OBJECTIVE:
B-1 Prevent roof drainage from entering storm sewers directly	Reduce the peak flow and/or volume of runoff

SUMMARY DESCRIPTION

This control measure would divert roof drainage away from storm sewers. For new construction, roof drains would be prohibited from connecting directly to storm drains. For existing structures, devices would be employed to spread runoff over porous surfaces (e.g., lawns and other landscaped surfaces), thereby reducing the overall volume of the runoff and/or its peak rate of discharge.

APPLICABILITY

This control measure would be most applicable* in suburban areas and developing areas (new developments and major redevelopments). The controls would be most cost-effective if they were made an integral part of new projects' design, since they can significantly effect decisions regarding building placement, site engineering, and landscaping. They probably have the highest likelihood of being applied when their use is made a requirement for gaining project approval via the building permit process. This control measure has the potential of benefiting water quality in systems where some form of runoff, storage and/or treatment is to be provided.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Most of the measures which can be applied to control water quality problems by reducing peak flows and volumes of runoff yield major benefits to other public works programs (e.g., flood control, water supply, groundwater recharge, erosion control, stormwater treatment). Because the major benefits of controlling roof runoff would be realized by these other public works programs, the decision whether or not to implement the measure should consider overall benefits and costs not just those related to water quality. Normally, the water quality benefits can be brought in as an additional form of justification in multiple-use projects (and hence improve the likelihood of approval and funding).

IMPLEMENTATION REQUIREMENTS

Administrative requirements

This control measure would have to be approved, financed, and implemented. It would place demands on public works and administrative staffs.

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*There are some sites where local conditions would limit the effectiveness of this control measure (e.g., infiltration would be limited in areas with a high water table and/or impervious soils).

Legal/political considerations

In some areas, it would be necessary to amend existing building and/or sewer ordinances to restrict the discharge of roof drainage directly into storm sewers (most areas' ordinances currently prohibit discharge to sanitary sewers). For new construction, implementation would consist of inspection and enforcement.

For existing structures, a public education campaign could be conducted to encourage retrofitting of roof drainage systems. Incentives could include tax deductions for building owners.

Fiscal considerations

The cost of disconnecting roof drains and rerouting on-site drainage would be borne by property owners. The cost of inspection would probably be borne by the building inspection or other public works programs.

POTENTIAL IMPACTS

No significant environmental or socioeconomic impacts are generally associated with this control measure.

COST CONSIDERATIONS

Control of roof drainage will require a program of establishing ordinances and inspecting existing and new sewers. There would be only minimal cost associated with establishing the required ordinances. Inspection and disconnection costs have been estimated at $3 per building inspected and $4 per downspout removed. The cost of this program could be offset by the benefits realized in flow reduction.

EVALUATION

Portion of the overall problem this measure would affect

The volume of rain which falls on roofs relative to other surfaces is a function of building density. In rural areas it is a relatively small portion of the total runoff; in urban areas, it becomes the major portion.

Potential effectiveness on affected portion

Theoretically, this control measure would divert and/or detain 100% of rooftop drainage.

Anticipated effectiveness in actual practice

At this stage of analysis, it is not possible to make meaningful predictions of the overall effectiveness of controlling roof drainage.

CONTROL MEASURE:	OBJECTIVE:
B-3 Direct runoff away from areas that contain contaminants	Reduce the pollutants carried by runoff

SUMMARY DESCRIPTION

This control measure would consist of constructing ditches, berms, and other devices to divert runoff away from areas where pollutant accumulation is likely to be high. This diversion would reduce the amount of pollutants which could be picked up by runoff and thus reduce the adverse impact of runoff on receiving waters.

APPLICABILITY

This control measure is applicable to areas that are known to contain large concentrations of potential contaminants (e.g., feedlots, parking lots, bulk chemical storage areas, junk yards, refuse landfills, and other waste material storage areas.

Control would probably be most effective on proposed new projects anticipated to have such land use, since they would typically require public approval. At that stage, the permitting process gives the public and local planning, public works, and public health agencies considerable leverage.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

In some cases the diversion structures constructed for this control measure could also be valuable in protecting property and/or providing flood control. To the extent that the diversion does benefit other public programs, the multiple use aspects of the system should be taken into account. Thus, the decision whether or not to implement the measure should consider overall costs and benefits - not just those related to water quality.

IMPLEMENTATION REQUIREMENTS

Technical aspects

The required ditches, berms, detention ponds, and other drainage course modifications would have to be designed and constructed.

Administrative requirements

This control measure could be implemented with least difficulty if the commitment to provide such systems is required as a prerequisite of some public permitting process (e.g., grading or building permit). Such facilities could be required before the permit is issued, or before participating agencies will certify that permit.

Legal/political considerations

City and county governments typically have the authority to impose restrictions regarding land use, grading, surface drainage, and the discharge of harmful materials to sewer systems and receiving waters. What is required here is to identify situations where localized contamination of runoff occurs and then devise a legal/political strategy for exercising the existent authority.

Potential effectiveness on affected portion

This control measure could potentially divert all runoff away from known areas of pollutant accumulation.

Anticipated effectiveness in actual practice

In actual practice, the diversion structures can be expected to divert virtually all of the runoff from polluted areas, thereby effectively removing each "treated" source from the problem.

Fiscal considerations

The cost for this control measure would typically be borne by the landowner, the developer, or a public improvement district (on either a solitary or a cost-sharing basis).

POTENTIAL IMPACTS

Environmental impacts

Implementation of this control measure would cause some temporary environmental impacts during the construction phase. There would also be some impacts during the operational phase (e.g., dust, noise, and air pollutant emissions, energy use). Some would result in localized alterations of the groundwater tables and could introduce runoff-borne contaminants into groundwater aquifers.

The diversion structures should be designed to minimize their impact on critical land uses such as agriculture and unique landforms. If carefully landscaped, they could add to the visual aesthetics of the site and could even provide valuable habitat for desirable small animals and birdlife in some applications. If not carefully designed and maintained, some such diversion systems could accumulate runoff and retain it for extended periods, thereby giving rise to local problems of stagnant water and its associated odor and/or vector breeding potential.

Socioeconomic impacts

Implementation of this control measure would yield employment opportunities in both the public and private sectors (e.g., engineering, landscape design, construction, inspection, administration). It is conceivable that the requirement for such controls could sufficiently increase the cost of developing some sites and/or operating existing facilities to the point that some projects would be forfeited. Case-by-case analysis would be required to determine whether the adverse effect of forfeiting the associated employment and tax revenues would be compensated by the benefits of water pollution control.

COST CONSIDERATIONS

Costs of such diversions would vary considerably from site to site, depending upon such factors as site area, terrain, local hydrographic conditions, access to the storm drainage system, soil type, and availability of suitable construction materials.

EVALUATION

Portion of the overall problem this measure would affect

Diverting flow from known areas of pollutant accumulation will deal only with the pollutants which could have been washed off of such areas.

CONTROL MEASURE:	OBJECTIVE:
B-2 Detain precipitation on rooftops	Reduce the peak flow and volume of runoff

SUMMARY DESCRIPTION

This measure is actually a specific application of Control Measure B-12 which would involve the temporary storage of precipitation such that the peak runoff flow rate could be reduced. This could lessen runoff-induced water quality problems in two ways: it would reduce the short-term shock loading of receiving waters; and it would reduce the required capacity of any treatment facilities. It could also reduce the overall volume of runoff in some applications, if the eventual discharge from the rooftop drains were detained so as to allow more time for ground infiltration. The temporary storage would be achieved by providing scupper/drain systems with flow controlling devices (ranging from small orifices or weirs to automatic time-controlled valves).

APPLICABILITY

Such drainage control systems would be applicable only on virtually flat roofs of competent structural integrity. They would be most applicable on relatively large buildings and in areas where buildings cover a large portion of the land area (e.g., downtown areas, large commercial/industrial complexes, schools).

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure could provide an important benefit to flood control programs. For that reason, the decision whether to implement this measure should consider all benefits and costs - not just those related to runoff water quality.

IMPLEMENTATION REQUIREMENTS

<u>Technical aspects</u>
Roofs would have to be carefully inspected for water tightness and structural integrity. Scuppers, gutters, drainpipes and/or other parts of the drainage system would have to be modified to detain precipitation and release it at a predetermined rate.

<u>Administrative requirements</u>
The only demand for administrative effort would be that associated with promoting the concept of implementing this measure and inspecting the resultant systems (at the time of completion and periodically thereafter).

<u>Legal/political considerations</u>
No legal/political constraints are anticipated, as long as the assessment of the roof's structural integrity adequately considers building code requirements. To avoid potential problems of liability, the practice of providing rooftop storage would probably be made voluntary on privately-owned buildings (not mandatory).

POTENTIAL IMPACTS

Retained water could be held and used in a variety of ways later on (e.g., for cooling and heating systems, landscape irrigation, fire prevention, washing).

EVALUATION

Portion of the overall problem this measure would affect

The volume of rain which falls on roofs relative to other surfaces is a function of building density. In rural areas it is a relatively small portion of the total runoff; in urban areas it becomes the major portion. In downtown areas, runoff could be reduced by up to 30 to 50%.

Potential effectiveness on affected portion

Theoretically, this control measure would detain 100% of rooftop drainage.

Anticipated effectiveness in actual practice

At this stage of analysis, it is not possible to make meaningful predictions of the overall effectiveness of controlling roof drainage.

REFERENCES

Abt Associates, Inc. 1977. Preventive Approaches to Stormwater Management. EPA 440-0-77-001. 207 pp.

Poertner, H. 1974. Practices in Detention of Urban Stormwater Runoff. Office of Water Resources Research Contract No. 14-31-0001-3722.

CONTROL MEASURE:	OBJECTIVE:
B-4 Retain runoff from areas which contain contaminants	Reduce the accumulation of pollutants prior to runoff

SUMMARY DESCRIPTION

This control measure consists of constructing ditches, berms, and other devices to collect the runoff from areas which contain large amounts of potential pollutants and conveying the contaminated runoff to detention ponds or treatment devices. This would serve to prevent the runoff from polluted areas from combining with the runoff from the surrounding locale. It is assumed that the collected runoff would be given adequate treatment before discharge or reuse. This control measure effectively converts an area-wide or non-point-source into a point-source of water pollution, thereby simplifying control.

APPLICABILITY

This control measure is applicable to areas that are known to contain large concentrations of potential contaminants (such as feedlots, parking lots, bulk chemical storage areas, junk yards, refuse landfills, and other waste material storage sites).

Control would probably be most effective on proposed new projects anticipated to have such land use, since they would typically require public approval. At that stage, the permitting process gives the public and local planning, public works, and public health agencies considerable leverage.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

In some cases the diversion structures constructed for this control measure could also be valuable in protecting property and/or providing flood control. To the extent that the diversion does benefit other public programs, the multiple use aspects of the system should be taken into account. Thus, the decision whether or not to implement the measure should consider overall costs and benefits - not just those related to water quality.

IMPLEMENTATION REQUIREMENTS

Technical aspects

The required ditches, berms, detention ponds, and other drainage course modifications would have to be designed and constructed.

Administrative requirements

This control measure could be implemented with least difficulty if the commitment to provide such systems is required as a prerequisite of some public permitting process (e.g., grading or building permit). Such facilities could be required before the permit is issued, or before participating agencies will certify that permit.

Legal/political considerations

City and county governments typically have the authority to impose restrictions regarding land use, grading, surface drainage, and the discharge of harmful materials to sewer systems and receiving waters. What is required here is to identify situations where localized contamination of runoff occurs and then devise a legal/political strategy for exercising the existent authority.

Fiscal considerations

The cost for this control measure would typically be borne by the landowner, the developer, or a public improvement district (on either a solitary or a cost-sharing basis).

POTENTIAL IMPACTS

Environmental impacts

Implementation of this control measure would cause some temporary environmental impacts during the construction phase. There would also be some impacts during the operational phase (e.g., dust, noise, and air pollutant emissions, energy use). Some would result in localized alterations of the groundwater tables and could introduce runoff-borne contaminants into groundwater aquifers. The diversion structures should be designed to minimize impact on critical land uses such as agriculture and unique landforms. If carefully landscaped, they could add to the visual aesthetics of the site and could even provide valuable habitat for desirable small animals and birdlife in some applications. If not carefully designed and maintained, some such diversion systems could accumulate runoff and retain it for extended periods, thereby giving rise to local problems of stagnant water and its associated odor and/or vector breeding potential.

Socioeconomic impacts

Implementation of this control measure would yield employment opportunities in both the public and private sectors (e.g., engineering, landscape design, construction, inspection, administration). It is conceivable that the requirement for such controls could sufficiently increase the cost of developing some sites and/or operating existing facilities to the point that some projects would be forfeited. Case-by-case analysis would be required to determine whether the adverse effect of forfeiting the associated employment and tax revenues would be compensated by the benefits of water pollution control.

COST CONSIDERATIONS

Costs of such diversions would vary considerably from site to site, depending upon such factors as site area, terrain, local hydrographic conditions, access to the sanitary sewers and/or treatment facilities, soil type, and availability of suitable construction materials.

EVALUATION

Portion of the overall problem this measure would affect

Retaining runoff within known areas of pollutant accumulation will deal only with the pollutants which could have been washed off of such areas.

Potential effectiveness on affected portion

This control measure could potentially retain all runoff from known areas of pollutant accumulation.

Anticipated effectiveness in actual practice

In actual practice, this measure can be expected to retain virtually all of the runoff from polluted areas, thereby effectively removing each source from the problem.

REFERENCES

R. Loehr. 1974. "Characteristics and Comparable Magnitude of Non-Point Sources", J. Water Pollution Control Federation, 46, 1849.

CONTROL MEASURE:	OBJECTIVE:
B-5 Impound runoff in upstream channels	Reduce the peak flow or volume of runoff

SUMMARY DESCRIPTION

This measure consists of constructing permanent, though often simple, modifications of upstream drainage channels in order to store a portion of the stormwater runoff and reduce the stress on downstream facilities. The storage can be either of a short-term or long-term nature. Although runoff control is the primary purpose, retention impoundments, especially, can be designed to serve multiple objectives. Impoundments can be either in-line or off-line of the modified waterway. Common examples would include channel enlargements, man-made ponds, and storage basins. Dams and weirs, diversion channels, and gabions are also frequently used retention structures. This control measure would serve to reduce peak flow and/or the overall volume of runoff to be dealt with downstream.

APPLICABILITY

The principal application of this measure would be in support of systems which would treat runoff (i.e., impoundments tend to equalize flows thereby reducing peak capacity requirement of treatment facilities). There are virtually no such treatment facilities in the Bay Area at present. Therefore impoundments would probably be provided only as part of new, integrated storage/treatment schemes which may be proposed (rather than being implemented by themselves). This control measure would also be applicable in combined sanitary/storm sewer systems and in certain areas where uncontrolled surface runoff tends to overload sanitary sewers during storm events.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This measure would benefit flood control programs, and would probably be funded for that reason. It can reduce requirements for sewerage system and other downstream structural controls. Shock loading of treatment facilities following a storm can be reduced when impoundments serve to reduce the tendency to scour deposits built up within sewer lines. Groundwater recharge programs could be benefitted in cases where the impoundment is located within recharge zones. Permanent impoundments can be used as recreational or water supply facilities. Impounded water can be employed for irrigation and street cleaning and flushing, and other uses.

IMPLEMENTATION REQUIREMENTS

Technical aspects

This control measure would be most effective where application is preceded by careful hydrologic studies. Physical implementation could be as minor as making simple stream channel modifications or could be as extensive as building structural controls in the form of dams, berms, inlet and outlet devices (to control discharge), and other systems. Some of these would require considerable design and construction efforts and materials (e.g., fill, concrete, aggregate).

Administrative requirements

Where the above control measure is implemented on public projects, there would be demands on public works personnel during the design, construction, and operational phases. Where it is implemented on private projects (via requirements set forth by law or public policy), there would be some need for public works and/or planning department staff involvement during the design, construction, and operational phases (to assure that the system functions as intended by the requirements).

Legal/political considerations

In most cases implementation would require resolving issues related to water rights, land use, land ownership, and tenure.

POTENTIAL IMPACTS

Environmental impacts

The impoundments may require the use of or otherwise interfere with critical land resources (e.g., prime agriculture, forest). Such alteration of stream flow regimes would have pronounced effects on riparian ecosystems. Consideration should be given to the possibility of adverse health effects from vector breeding in or around impoundments. Potential impacts on groundwater quality need to be assessed on a case-by-case basis.

Socioeconomic impacts

The design, construction, and maintenance of impoundment areas would create additional employment opportunities. Where this control measure is associated with new development projects, increased housing or other consumer costs can be expected. In some cases the impoundments could be used to provide recreational and scenic amenities as well as additional protection against flooding. The public safety aspects of such impoundments developing into "attractive nuisances" need to be assessed on a case-by-case basis.

EVALUATION

Portion of the overall problem this measure would affect

This measure would allow the treatment of stormwaters which would otherwise exceed the throughput capacity of treatment facilities (had there been no detention). The effectiveness of the measure can be determined by considering the incremental increase in volume of runoff which could be treated and the degree of treatment (i.e., the facilities' removal efficiencies for BOD, suspended solids, etc). This would have to be assessed on a case-by-case basis.

Potential effectiveness on affected portion

As noted above, the effectiveness depends upon the treatment facilities' removal efficiencies for the various pollutants (see Control Measure C). Note that there are few installations in the Bay Area where stormwater is treated. Hence, the analysis would generally be for new facilities.

Anticipated effectiveness in actual practice

This cannot be assessed on a general basis.

COST CONSIDERATIONS

Costs of the facilities for impounding runoff in upstream channels would vary significantly, depending upon such factors as the size of impoundment, terrain, stream hydrographs, soil type, geology, the need for inlet or outlet flow regulation, and the other uses to which the impoundment would be put (e.g., flood control, water supply, fishing, other recreation). Estimated costs for constructing simple, in-channel check dams are summarized in Table B-5-a.

TABLE B-5-a

ESTIMATED UNIT COST FOR CHECK DAM

Item	Cost $/sq yd
Materials:	
Gabions 6'x3'x1' @ $20/ea	10.00
Rock @ $6/cu yd	2.00
	12.00
Labor (assuming 10 sq yd/hr):	
Truck Driver @ $15/hr	1.50
Loader Operator @ $12/hr	1.20
5 Laborers @ $11/hr	5.50
	8.20
Equipment:	
Dump Truck @ $15/hr	1.50
Front-end Loader @ $10/hr	1.00
	2.50
TOTAL	22.70

EXAMPLES

There are a variety of impoundment installations in use throughout the Bay Area, but none are known to have been designed for this particular purpose. For information on examples elsewhere, see the following references.

REFERENCES

Field, R., Tafuri, A., Masters, H. 1977. Urban Runoff Pollution Control Technology Overview. Wastewater Research Division, Municipal Environmental Research Laboratory. Edison, New Jersey. EPA-600/2-77-047. 91pp.

Tourbier, J., Westmacott, R. 1974. Water Resources Protection Measures In Land Development — A Handbook. University of Delaware Water Resources Center. Newark, Delaware. 237pp.

County of Fairfax, Virginia. 1976. Public Facilities Manual, Volume III, Tree Preservation and Planting, Erosion and Sediment Control. 309pp.

Tahoe Regional Planning Agency. 1977. Lake Tahoe Basin Water Quality Management Plan, Volume II, Handbook of Best Management Practices.

Hittman Associates, Inc. 1973. Processes, Procedures, and Methods to Control Pollution Resulting From All Construction Activity. Columbia, Maryland, EPA 430/9-73-007. 234pp.

The following public agencies have considerable expertise in dealing with erosion problems:

U.S. Geological Survey
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
USDA, Soil Conservation Service
Resource Conservation Districts

CONTROL MEASURE:	OBJECTIVE:
B-8 Regrade Disturbed Areas	Reduce the amount of pollutants and the peak flow and/or volume of runoff

SUMMARY DESCRIPTION

This measure consists of reshaping or retexturing presently eroding ground surfaces by applying various grading practices such as cut and fill, surface roughening techniques (e.g., scarification, tracking), and alteration of slope faces (e.g., terraces, benches, ditches). Through slope modification and surface roughening, both the velocity and direction of runoff can be controlled. Proper use of these measures can reduce erosion, increase infiltration, prevent soil slippage, and facilitate the establishment of vegetation. Such physical changes in the ground surface would benefit runoff quality by reducing erosion and the peak flow and/or volume of runoff.

APPLICABILITY

Some form of this control measure could apply to nearly all situations in which ground surfaces and slopes are potentially erodable.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Most major construction and landscaping projects involve measures related to the strategic grading of soil surfaces and are generally combined with revegetation practices and planned diversion structures (e.g., concrete channels, retaining walls). Effective programs of controlling erosion would serve communities' overall land use and water quality management programs. They would be closely related to sediment control and stormwater management operations, as well as the measures designed to control other pollutants from construction sites (i.e., other than sediment). The benefits of erosion control are so great and so varied that the decision whether or not to implement such controls should consider all benefits to both the public and private sectors (and not just the water quality benefits).

IMPLEMENTATION REQUIREMENTS

Technical aspects

For most surface modifications a bulldozer equipped with bucket "teeth" would be needed. Trucks for hauling fill or removed material might also be necessary along with a vehicle to transport the dozer. Support requirements would include facilities for maintenance, parts, and fuel.

Administrative requirements

Effective implementation of this measure may depend upon making technical planning expertise available to guide and advise contractors. Inspection of the site during and after corrective construction is essential to monitor the success of erosion control operations. Such efforts would place demands on administrative, planning, and public works staffs. If the entire burden of controlling erosion could be placed on developers (by means of stringent permit requirements) there would be little need for such involvement by public agencies.

Legal/political considerations

Standards and specifications for grading exist for some jurisdictions at the county and local levels of government. Regrading plans should assess how adjoining properties are likely to be affected.

POTENTIAL IMPACTS

Environmental impacts

Implementation of these types of control measures would cause some temporary environmental impacts during the construction phase (e.g., dust, noise, and air pollutant emissions, energy use). There could also be some impacts after construction. Some could result in higher groundwater tables. Negative impacts on aesthetics, vegetation, and wildlife habitats normally result from grading practices. Plans to alter the original slope and terrain characteristics of a site should be carefully evaluated prior to grading. Disturbance of the vegetative cover should be kept to a minimum and care should be taken with remaining specimen trees. After grading, erosion controls should be implemented so as to avoid stream siltation with subsequent impact to aquatic ecosystems and suffocation of vegetation on the site.

Socioeconomic impacts

Implementation of these control measures would yield employment opportunities in both the public and private sectors (e.g., engineering, landscape design, construction, inspection, administration). It is conceivable that the requirement for such controls would increase the cost of developing some sites which could be passed on to land owners or prospective home buyers.

COST CONSIDERATIONS

The cost of conducting regrading operations cannot be estimated on a general, non-site-specific basis. The designer should keep the following general guidelines in mind when planning and making cost estimates.

Generally cut slopes are never graded steeper than 2:1 and fill slopes 2.5-3:1, and a 3:1 slope is generally considered to be the maximum slope on which maintenance equipment can operate. Erodibility will depend on such factors as gradient, length of slope, volume of runoff and soil type. Any effective reduction in gradient, length of slope or volume of runoff will significantly reduce erosion. In cases where it is not feasible to decrease the gradient of the slope, its effective length can be reduced by constructing terraces, or benches across the slope. These intercept runoff and direct it along the contour, effectively reducing the hydraulic gradient, increasing the overland flow time and the time of concentration.

EVALUATION

Portion of the overall problem this measure would affect

To the extent that such control practices can be applied as corrective treatments of the existing erosion problems, they could have the effect of reducing current runoff problems. It is not possible to estimate the extent to which this potential could be realized, given the present knowledge of conditions in the Bay Area.

Potential effectiveness on affected portion

Well managed erosion control programs could reduce soil loss from major construction sites on the order of 90%+.

Anticipated effectiveness in actual practice

Soil loss could be reduced by as much as 90%, but the actual effectiveness will depend entirely upon the degree to which the developer is required to actually implement and maintain the various measures.

EXAMPLES

Cut and filled slopes have been given careful grading treatment on many of the newer freeways.

REFERENCES

Tourbier, J., Westmacott, R. 1974. Water Resources Protection Measures in Land Development — A Handbook. University of Delaware Water Resources Center. Newark, Delaware. 237 pp.

County of Fairfax, Virginia. 1976. Public Facilities Manual, Volume III, Tree Preservation and Planting, Erosion and Sediment Control. 309 pp.

Tahoe Regional Planning Agency. 1977. Lake Tahoe Basin Water Quality Management Plan, Volume II, Handbook of Best Management Practices.

Maryland Dept. of Water Resources and Hittman Associates, Inc. 1972. Guidelines for Erosion and Sediment Control Planning and Implementation. EPA-R2-72-015. 229 pp.

The following Public Agencies have considerable expertise in dealing with the proper grading of erodable slopes.

U.S. Geological Survey
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
USDA, Soil Conservation Service
FHA, HUD
Resource Conservation Districts
CalTrans

CONTROL MEASURE:	OBJECTIVE:
B-10 Stabilize stream channels and banks.	Reduce the amount of pollutants and the peak flow or volume of runoff.

SUMMARY DESCRIPTION

This measure consists of a broad range of vegetative and structural practices designed to hold soil together and dissipate the erosive energy of streamflow. The choice of practice is dependent on the size of the waterway, the soil conditions, the flow velocity, the stream gradient, and cost. Vegetative practices such as seeding and sodding are the most desirable types of stabilization measures, especially for minor waterways. The use of grasses not only stabilizes soil and reduces current energy, but also filters sediment and maximizes infiltration.

In conditions of high flow velocity (>8 fps), poor soil conditions, or high water table, structural practices are required. Three basic types exist: grade control, bank protection, and channel lining. The most common grade control device is the check dam, a drop structure which flattens the slope of streams, thereby dissipating energy. One common method of bank protection is provided by revetments, which may be rigid (concrete, asphalt, sacked cement) or flexible (gabions, riprap, Fabriform). Jettys and current deflectors of wood, stone, or concrete also protect banks by deflecting the current away from critical bank areas. Channel linings represent the most severe structural practice. The lining can be made of impermeable (concrete) or semipermeable (dropped stone, ungrouted riprap) materials.

Frequently, combinations of vegetative-structural practices are used. To further aid erosion control, special devices such as energy dissipators and erosion checks can be used. In particular, energy dissipators have proven to be an economical and reliable means of lessening flow velocity in critical areas (i.e., immediately downstream from channel constrictions and drop structures).

APPLICABILITY

Upstream urban development often necessitates some type of channel stabilization. Development accelerates channel and bank erosion by increasing runoff constricting channels, increasing channel grade by realignment and shortening of waterways and destroying vegetation. This measure applies to both major and minor waterways.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Channel stabilization practices are normally designed to assist flood control programs. The vegetative practices can assist groundwater recharge programs.

IMPLEMENTATION REQUIREMENTS

Technical aspects

This control measure would be most effective where application is preceded by careful hydrologic studies. Physical implementation could be as minor as making simple stream channel modifications or could be as extensive as building structural controls in the form of dams and other systems. Some of these would require considerable design and construction efforts and materials (e.g., fill, concrete, aggregate).

Administrative requirements

Where the above control measure is implemented on public projects, there would be demands on public works personnel during the design, construction, and operational phases. Where it is implemented on private projects (via requirements set forth by law or public policy), there would be some need for public works and/or planning department staff involvement during the design, construction, and operational phases (to assure that the system functions as intended by the requirements).

Legal/political considerations

In most cases implementation would require resolving issues related to land use, land ownership, and tenure.

POTENTIAL IMPACTS

Environmental impacts

The channel modifications may require the use of or otherwise interfere with critical land resources (e.g., prime agriculture, forest). Such alteration of stream flow regimes would have pronounced effects on riparian ecosystems. Potential impacts on groundwater need to be assessed on a case-by-case basis.

Socioeconomic impacts

The design, construction, and maintenance of channel stabilization measure would create additional employment opportunities. Where this control measure is associated with new development projects, increased housing or other consumer costs can be expected. In some cases the measures could be used to provide recreational and scenic amenities as well as additional protection against flooding. The public safety aspects of impoundments developing into "attractive nuisances" needs to be assessed on a case-by-case basis.

COST CONSIDERATIONS

Cost of the facilities for stabilizing stream channels would vary significantly, depending upon such factors as the terrain, stream hydrographs, soil type, geology, and the other uses to which the stream would be put (e.g., water supply, fisheries, recreation). Estimated costs for constructing simple, in-channel check dams are summarized in Table B-10-a.

EVALUATION

The effectiveness of controlling water quality by stabilizing stream channels and banks cannot be predicted except on a case-by-case basis.

TABLE B-10-a

ESTIMATED UNIT COST FOR CHECK DAM

Item	Cost $/sq yd
Materials:	
Gabions 6' x 3' x 1' @ $20/ea	10.00
Rock @ $6/cu yd	2.00
	12.00
Labor (assuming 10 sq yd/hr):	
Truck Driver @ $15/hr	1.50
Loader Operator @ $12/hr	1.20
5 Laborers @ $11/hr	5.50
	8.20
Equipment:	
Dump Truck @ $15/hr	1.50
FE Loader @ $10/hr	1.00
	2.50
TOTAL	22.70

EXAMPLES

There are a variety of facilities for stream stabilization in use throughout the Bay Area. For information on examples elsewhere, see the following references.

REFERENCES

Field, R., Tafuri, A., Masters, H. 1977. Urban Runoff Pollution Control Technology Overview. Wastewater Research Division, Municipal Environmental Research Laboratory. Edison, New Jersey. EPA-600/2-77-047. 91 pp.

Tourbier, J., Westmacott, R. 1974. Water Resources Protection Measures in Land Development - A Handbook. University of Delaware Water Resources Center. Newark, Delaware. 237 pp.

County of Fairfax, Virginia. 1976. Public Facilities Manual, Volume III, Tree Preservation and Planting, Erosion and Sediment Control. 309 pp.

Tahoe Regional Planning Agency. 1977. Lake Tahoe Basin Water Quality Management Plan, Volume II, Handbook of Best Management Practices.

Hittman Associates, Inc. 1973. Processes, Procedures, and Methods to Control Pollution Resulting From All Construction Activity. Columbia, Maryland. EPA 430/9-73-007. 234 pp.

The following public agencies have considerable expertise in dealing with stream erosion problems:

U.S. Geological Survey
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
USDA Soil Conservation Service
Resource Conservation Districts

CONTROL MEASURE:	OBJECTIVE:
B-12 Enhance surface retention and infiltration to minimize alteration of natural rainfall/runoff relationships	Reduce the peak flow and/or volume of runoff

SUMMARY DESCRIPTION

This measure encompasses a variety of physical features which could be incorporated into landscape and building designs such that the peak flows and total volumes of storm runoff would be reduced (see attached table). Included would be measures to temporarily detain overland flow, measures to enhance infiltration, and measures to temporarily store stormwater on-site. Overland flow could be detained through modification of ground surface textures (e.g., scarifying or perforating the exposed soil surface, providing special pavements or ground covers, landscape planting) and/or careful design of terrain contour. Infiltration could be enhanced by strategic landscaping and the use of permeable ground covers and pavements (e.g., cobbles, bricks, porous pavement, Grasscrete). On-site storage of stormwater could be in ponds or small lakes, specially-constructed retention basins, parking lots, or even on rooftops (see Control Measure B-2) — all strategically located and equipped with discharge controls to release runoff such that the site hydrograph is as close as possible to what it would have been without development. See the attached table for examples of such control measures.

APPLICABILITY

Such control measures would be most applicable* in developing areas (new developments and major redevelopments). The concepts would be most cost-effective if they were made an integral part of the projects' design, since they can significantly affect decisions regarding building placement, site engineering, and landscaping. They probably have the highest likelihood of being applied when their use is made a requirement for gaining project approval via the grading and/or building permit process.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Most of the measures which can be applied to control water quality problems by reducing peak flows and volumes of runoff, yield major benefits to other public works programs (e.g., flood control, water supply, groundwater recharge, erosion control, stormwater treatment). Because many of the major benefits of the above control measures would be realized by these other public works programs, the decision whether or not to implement the measures should consider overall benefits and costs — not just those related to water quality. Normally, the water quality benefits can be brought in as an additional form of justification in multiple-use projects (and hence improve the likelihood of approval and funding).

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*There are some sites where local conditions would limit the effectiveness of some such control measures (e.g., infiltration would be limited in areas with a high water table and/or impervious soils).

IMPLEMENTATION REQUIREMENTS

Technical aspects

These control measures are most effective where application is preceded by careful studies of site hydrology. Physical implementation could be as simple as arranging buildings and land use to favor the desired runoff pattern or could be as extensive as providing structural controls in the form of outlet devices (to control discharge), dams, berms, porous paving, and the other systems described earlier. Some of these might require considerable design and construction efforts and materials (e.g., fill, concrete, aggregate, steel).

Administrative requirements

Where the above control measures are implemented on public projects, there would be demands on public works personnel during the design, construction, and operational phases. Where they are implemented on private projects (via requirements set forth by law or public policy), there would be some need for public works and/or planning department staff involvement during the design, construction, and operational phases (to assure that the system functions as intended by the requirements).

Legal/political considerations

The broadest application of these control measures would result where they are required as a special provision prior to issuing grading and/or building permits. In most areas, this would require amending existing permitting process (i.e., developing and adopting ordinances and setting up mechanisms for review and enforcement). The provisions should generally require that the applicant (i.e., the private or public developer) submit plans for physical systems which will assure that the rainfall/runoff relationships at the site would not be significantly different than what they would have been under natural conditions. The burden of proving compliance should be placed on the would-be developer. Note that such controls could interfere with water rights in some circumstances (e.g., retention and storage systems).

POTENTIAL IMPACTS

Environmental impacts

Implementation of these types of control measures would cause some temporary environmental impacts during the construction phase (e.g., dust, noise, and air pollutant emissions, energy use). There could also be some impacts after construction. Some would result in higher groundwater tables. Some could introduce runoff-borne contaminants into groundwater aquifers. If not carefully managed, some retention basins, ponds, and lakes could develop adverse water quality conditions and could provide breeding sites for insects or have adverse impacts on aquatic life, public health and safety, and aesthetics.

Socioeconomic impacts

Implementation of these control measures would yield employment opportunities in both the public and private sectors (e.g., engineering, landscape design, construction, inspection, administration). It is conceivable that the requirement for such controls could sufficiently increase the cost of developing some sites to the point that some development projects would be forfeited. Careful analysis would be required to determine whether the adverse effect of forfeiting the associated employment and tax revenues would be compensated by the avoidance of adverse downstream impacts related to flood, erosion, and water quality control. The requirements for such controls would increase the cost of site development and, in turn, result in higher housing prices. Such price increases would have a disproportionately negative impact on low and moderate income families. Careful analysis is required to determine if increased costs are compensated by the avoidance of on-site and downstream flood, erosion and water quality control.

COST CONSIDERATIONS

Costs of implementing these control measures would vary considerably from site to site depending on such factors as size of area involved, terrain, soil type, and depth to water table. Rough estimates for surface treatments range from $6 to 12 per sq yd of surface and $5 to 15 per 100 gal of water storage volume.

EVALUATION

Portion of the overall problem this measure would affect

The above-described control measures would have primary application to new developments and major redevelopment projects. Hence, they should not be seen as an important means for reducing present pollution problems from runoff. They are best viewed as a means by which an area could accommodate additional development with a minimum adverse impact.

Potential effectiveness on affected portion

These measures could trap some runoff-borne pollutants, but most of their effect would be to help control the peak rates and overall volumes of runoff. This could allow some treatment to be practiced (which would be impractical with very high flows) and it could reduce the impact which occurs for short time periods when the "first flush" of contaminated runoff is discharged into receiving waters.

Anticipated effectivensss in actual practice

The broad range of systems and potential applications precludes making any meaningful estimates of effectiveness.

EXAMPLES

See Table B-12-a. Local examples would include the use of Grasscrete pavement and a proposed retention pond at Redwood Shores (Redwood City).

Table B-12-a PRACTICES TO ENHANCE SURFACE RETENTION AND INFILTRATION

	How it Works	Example	Reference
Porous Pavement	Open-graded asphalt or concrete pavement would allow stormwater to infiltrate through to underlying soils as well as provide some temporary storage in void spaces.	U. of Delaware	Tourbier & Westmacott (1974) Thelen et al., (1972)
Dutch Drains and Concrete Lattice Blocks	Dutch drains are gravel-filled ditches which intercept surface runoff and allow percolation. Concrete lattice blocks and bricks provide a hard surface yet allow infiltration.	Embarcadero Center, San Francisco	Tourbier & Westmacott (1974)
Dry Wells	Dry wells are gravel or rubble-filled pits or trenches which facilitate infiltration. Since these wells are completely below grade, they would not alter overland flow, once full.		Tahoe Regional Planning Agency (1977)
Recharge Basins	Recharge basins can be dedicated or multi-purpose impoundments used for recharging groundwater aquifers with collected runoff	Long Island, Southern California	Tourbier & Westmacott (1974)
Injection wells	Injection wells are deeper, high-pressure versions of recharge basins.	Long Island, Southern California	Tourbier & Westmacott (1974)
Level Spreaders	Level spreaders are flat basins cut on a slope to facilitate infiltration.	Columbia, Maryland	Tourbier & Westmacott (1974)
Check Dams	Temporary and permanent check dams are constructed perpendicular to the direction of flow. They retard and pond flow to facilitate infiltration.		Chow (1964)

CONTROL MEASURE:	OBJECTIVE:
B-15 Control erosion at construction sites	Reduce the amount of pollutants which can be incorporated into the runoff

SUMMARY DESCRIPTION

This measure includes numerous structural and soil stabilization actions whose timely application can lessen erosion (see attached table). Effective erosion control programs should begin at the project planning stage, during which potential problems relating to soil, drainage, and terrain would be assessed and planned for. At this stage, decisions on the type of erosion control actions to be used can be made and then included in grading and building permit requirements as well as the contract. Specifications and schedules would be established for site grading, revegetation, and mulching and the subsequent inspection and maintenance of the control actions.

Although construction areas as a whole should be viewed as potentially erodable, attention should be focused on the most vulnerable zones (e.g., drainage-ways, cut and fill slopes, borrow areas, excavations, soil stockpiles, areas where dewatering is necessary). Erosion control actions would include: strategically staging the grading and revegetation programs; providing means for intercepting, diverting, collecting, and distributing runoff; using temporary or permanent ground surface covers; and treating soil with synthetic or natural soil binders.

APPLICABILITY

This control measure would be most applicable in developing areas (new developments and major redevelopments); but it could also be used as a corrective measure for areas where erosion is presently a problem. The concepts would be most cost-effective if they were made an integral part of the projects' design, since they can significantly affect decisions regarding building placement, site engineering, and landscaping. They probably have the highest likelihood of being applied when their use is made a requirement for gaining project approval via the grading and/or building permit process.

This measure could be applied to virtually all construction sites and all phases of construction activity from site planning to post-construction inspection and maintenance.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Effective programs of controlling construction site erosion would serve communities' overall land use and water quality management programs. They would be closely related to sediment control and stormwater management, and channel and sewer maintenance operations, as well as the measures designed to control other pollutants from construction sites (i.e., other than sediment). The benefits of erosion control are so great and so varied that the decision whether or not to implement such controls should consider all benefits to both the public and private sectors (and not just the water quality benefits).

IMPLEMENTATION REQUIREMENTS

Technical aspects

The attached tables summarize some of the pertinent technical issues regarding this control measure. Specific applications would vary widely, depending upon site conditions (e.g., soil type, terrain, cover).

Administrative requirements

Effective implementation of this measure may depend upon making technical and planning expertise available to guide and advise developers and contractors on erosion control. Assistance to builders during site planning on major construction projects is advisable. Inspection of construction activity during and after construction is essential to monitor the success of the erosion control operation, to recommend corrective measures, and possibly to enforce the erosion control requirements of the contract or building permit. Such efforts would place demands on administrative, planning, and public works staffs. If the entire burden of precluding eroded soils from site runoff can be placed on the developer (by means of stringent permit requirements) there may be little need for such involvement by public agencies.

Legal/political considerations

Government involvement in construction activity for the purpose of insuring adequate erosion control could be (and often is) exercised through permitting processes. The broadest and most effective application of erosion control measures would result where they are required as a special provision prior to issuing grading and/or building permits. The California Subdivision Map Act (California Government Code Sections 66411 et seq.) authorizes* local agencies to require erosion control practices as part of construction plan submittals. The extent to which local agencies require substantive plans and commitments of adherence varies considerably from agency to agency. To be most effective, a program of bond posting and a policy of charging the developer with the burden of proving compliance could be implemented.

POTENTIAL IMPACTS

Environmental impacts

Implementation of erosion control measures could cause some temporary environmental impacts during the construction phase (e.g., dust, equipment-related noise and air pollutant emissions, energy use). Some measures could be in conflict with the objective of reducing peak flows and values of runoff by routing runoff away from erodable (but pervious) areas and into less pervious diversion channels which tend to have short concentration times. Careful design should be able to arrive at a favorable balance. Wherever possible, native plant species compatible with on-site conditions and uses should be favored to minimize some of the ecosystem inbalances which can result from the indiscriminate use of imported species.

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*Note that further legal authority can be drawn from the provisions of the Federal Water Pollution Control Act Amendments of 1972 and the water quality criteria (re: suspended solids) expressed by the State Water Resources Control Board and the Regional Water Quality Control Boards.

Socioeconomic impacts

Implementation of these control measures would yield employment opportunities in both the public and private sectors (e.g., engineering, landscape design, construction, inspection, administration). It is conceivable that the requirement for such controls could sufficiently increase the cost of developing some sites to the point that some development projects would be forfeited. Careful analysis would be required to determine whether the adverse effect of forfeiting the associated employment and tax revenues would be compensated by the avoidance of adverse downstream impacts related to flood, erosion, and water quality control.

COST CONSIDERATIONS

The cost of controlling erosoin would vary widely depending upon such site-specific factors as terrain, soil type, rainfall rates, and the control measures potential effect on visual aesthetics. The unit costs summarized in Table B-15-b can be used as a guide to selecting among candidate approaches for specific sites. Table B-15-c summarizes the effectiveness of candidate ground covers.

EVALUATION

Portion of the overall problem this measure would affect

The above-described control measures would have primary application to construction in new developments and major redevelopments. Hence, their major benefits would come in the form of controlling future increases in runoff contamination rather than controlling current problems. However, to the extent that such control practices can be applied as remedial treatments of existing erosion problems, they could have the effect of reducing current runoff problems. It is not possible to estimate the extent to which this potential could be realized, given the present knowledge of conditions in the Bay Area.

Potential effectiveness on affected portion

Well managed erosion control programs could reduce soil loss from major construction sites on the order of 90%+.

Anticipated effectiveness in actual practice

Well managed erosion control programs could reduce soil loss from major construction sites on the order of 90%, but the actual effectiveness will depend entirely upon the degree to which the developer is required to actually implement and maintain the various measures.

EXAMPLES

A variety of erosion control practices are in common use throughout the Bay Area. For examples, see the attached references.

REFERENCES

Soil Conservation Service. 1969. Standards and Specifications for Erosion and Sediment Control in Urbanizing Areas. USDA. College Park, Maryland.

Soil Conservation Service. 1975. Guide for Erosion and Sediment Control in California. USDA. Davis, California.

Field, R., Tafuri, A., Masters, H. 1977. Urban Runoff Pollution Control Technology Overview. Wastewater Research Division, Municipal Environmental Research Laboratory. Edision, New Jersey. EPA-600/2-77-047. 91 pp.

*Tourbier, J., Westmacott, R. 1974. Water Resources Protection Measures in Land Development — A Handbook. University of Delaware Water Resources Center. Newark, Delaware. 237 pp.

*County of Fairfax, Virginia. 1976. Public Facilities Manual, Volume III, Tree Preservation and Planting, Erosion and Sediment Control. 309 pp.

Tahoe Regional Planning Agency. 1977. Lake Tahoe Basin Water Quality Management Plan, Volume II, Handbook of Best Management Practices.

Hittman Associates, Inc. 1973. Processes, Procedures, and Methods to Control Pollution Resulting from All Construction Activity. Columbia, Maryland. EPA 430/9-73-007. 234 pp.

University of Wisconsin. 1976. Non-Point Source Water Pollution, Part I. Non-Point Sources and Their Management. Water Resources Management Workshop. Madison, Wisconsin. 133 pp.

Maryland Dept. of Water Resources and Hittman Associates, Inc. 1972. Guidelines for Erosion and Sediment Control Planning and Implementation. EPA-R2-72-015. 229 pp.

*Abt Associates, Inc. Preventive Approaches to Stormwater Management. 1977. EPA 440/9-77-001. 207 pp.

The following Public Agencies have considerable expertise in dealing with erosion problems.

U.S. Geological Survey
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
USDA, Soil Conservation Service
FHA, HUD
Resource Conservation Districts
CalTrans

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*These references are particularly valuable and should definitely be consulted before making any important decisions regarding the application of this control measure.

Table B-15-a EROSION CONTROL METHODS

Surface roughening practices, such as scarification, "tracking", and the use of serrated slopes can reduce the amount of runoff and control the movement of water and sediment downhill. Scarification creates grooves along a slope and spreads the runoff horizontally, slowing its movement downhill. "Tracking" creates roughened surfaces by running a cleated tracker up and down slopes. Serrations can be cut into slopes by means of conventional bulldozers.

Interception and diversion devices divert runoff from clean areas to preclude erosion. Diversion structures include dikes, ditches, and terraces or benches. Disposal structures include flexible downdrains, sectional downdrains, flumes, and level spreaders. These devices divert the runoff into retention ponds or spread it on vegetated areas.

Grasses, legumes, vines, and other herbaceous plants, shrubs, and trees can be used to stabilize erodable surfaces.

Mulches, nettings, chemical binders, and rip-raps can be used as bank stabilization measures.

Table B-15-b. ESTIMATED COSTS OF EROSION CONTROL

SUMMARY OF COST ESTIMATES (For installation and maintenance)

Cost per lot, Townhouses — $50 - $75
Cost per lot, Subdivisions — $125 - $175
Cost per site — 2% - 4% of total contract cost
Cost per site — 10% of clearing and grading cost
Cost per acre, Subdivisions — $500 - $700
Cost per acre, Commercial/Industrial Proj — $250 - $450
Engineering costs (included above) — $50 - $60 per acre

MECHANICAL MEASURES

Initial Placement

Earth diversion berms — $20 - $35 per 100 LF
Straw bale barriers — $85 - $130 per 100 LF
Silt basins with earth dam:
  Watershed area — 2-25 acres — $600 - $1500
  Watershed area — 20-100 acres — $1500 - $4,000
  Watershed area — 100-200 acres — $4000 - $6000
Sodded ditches — $5 - $6 per LF
Level spreaders — $3 - $4 per LF
Rip-Rap — $25 per square yard, $20 per cu yd
Grouted Rip-Rap — $30 per sq yd
Reno mattress — $18 per sq yd
Gabion — $50 per cu yd

First Year's Maintenance

Earth diversion berms — $20 - $35 per 100 LF, per month
Straw bale barriers — $20 - $35 per 100 LF, per month
Silt Basins:
  Watershed area — 2-25 acres — $600 - $850 per year
  Watershed area — 25-100 acres — $850-1500 per year
  Watershed area — 100-200 acres — $1500 $2000 per year
Sodded Ditches — $20 - $35 per 100 LF, per month
Level Spreaders — $20 - $35 per 100 LF, per month

UNIT COSTS FOR MATERIALS

Straw Bales	$1.35 — 2.00 each
Fertilizer	6.30 — $10.00 per 80 lb.
Seed	
Kentucky 31	.40 — 75 per lb
Weeping Lovegrass	$15.87 — 16.00 per lb
Field Fence	
14-1/2 gauge — 4' x 360' rolls	.15 — .25 per LF
Welded Fence — 100' rolls	.40 — .45 per LF
Metal Fence Post — 6'	2.40 each
Corrugated plastic drain pipe	.20 — .25 per LF
Glassroot mulch	.07 — .08 per sq yd
Jute mesh	.85 — 1.15 per sq yd
Filter cloth	.12 — .15 per sq ft
Filter cloth	.12 — .15 per sq ft
Erosion net, 20,000 sq ft	$296.00
Staples for net, per 1000	$ 33.50

CHEMICAL MEASURES	Cost (per sq yd)	Cost (per acre)
Chemical stabilization only	$.12 - $.15	$580 - $730
Chemical stabilization w/seed and fertilizer	$.30 - $.35	$1450 - $1700
VEGETATIVE MEASURES		
First year's maintenance		
Temporary seeding	$.12 - $.18	
Permanent seeding	$.29 - $.35	
Sodding	$.90 - $2.00	
Initial Placement Costs		
Temporary seeding — by machine		
Seedbed preparation	$.02 - $.03	$100 - $145
Seed and application	$.02 - $.05	$100 - $240
Total without mulch	$.04 - $.08	$200 - $385
Mulch at 2 tons/acre	$.08 - $.10	$385 - $485
Total with mulch	$.12 - $.18	$585 - $870
Hydroseed with chemical tack	$.30 - $.35	$1450 - $1700
Temporary seeding — by hand		
Seedbed preparation	$.04 - $.06	$200 - $290
Seed and application	$.04 - $.10	$200 - $485
Total without mulch	$.08 - $.16	$400 - $775
Mulch at 2 tons/acre	$.16 - $.20	$800 - $1000
Total with mulch	$.24 - $.36	$1200 - $1775
Permanent seeding — by machine		
Seedbed preparation	$.09 - $.10	$445 - $485
Seed and application	$.12 - $.15	$585 - $725
Total without mulch	$.21 - $.25	$1030 - $1210
Mulch at 2 tons/acre	$.08 - $.10	$385 - $485
Total with mulch	$.29 - $.35	$1415 - $1695
Sodding (includes seedbed preparation)	$.90 - $2.00	$4350 - $9700
Mulch alone		
By hand	$.16 - $.20	$800 - $100
By machine	$.08 - $.10	$385 - $485

Table B-15-c Effectiveness of Ground Cover on Erosion and Sediment Control on Construction Sites

Kinds of Ground Cover	Soil Loss Reductions Related to Bare Surfaces
Permanent grasses*	99%
Ryegrass (perennials)*	95
Ryegrass (annuals)*	90
Small grain*	95
Millet or sudangrass*	95
Grass sod	99
Hay (2 tons/acre)	98
Small grain straw (2 tons/acre)	98
Corn stalks (4 tons/acre)	98
Woodchips (6 tons/acre)**	94
Wood cellulose fiber (1-3/4 tons/acre)**	90
Fiberglass (1000 lbs/acre)**	95
Asphalt emulsion (1250 gal/acre)	98

*Values of seeded vegetation are based upon a fully established stand.

**Based on research in progress. In-service use only.

Reference: USDA, Agricultural Research Service.

REFERENCES

Soil Conservation Service. 1969. Standards and Specifications for Erosion and Sediment Control in Urbanizing Areas. USDA. College Park, Maryland.

Soil Conservation Service. 1975. Guide for Erosion and Sediment Control in California. USDA. Davis, California.

Field, R., Tafuri, A., Masters, H. 1977. Urban Runoff Pollution Control Technology Overview. Wastewater Research Division, Municipal Environmental Research Laboratory. Edision, New Jersey. EPA-600/2-77-047. 91 pp.

*Tourbier, J., Westmacott, R. 1974. Water Resources Protection Measures in Land Development — A Handbook. University of Delaware Water Resources Center. Newark, Delaware. 237 pp.

*County of Fairfax, Virginia. 1976. Public Facilities Manual, Volume III, Tree Preservation and Planting, Erosion and Sediment Control. 309 pp.

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Hittman Associates, Inc. 1973. Processes, Procedures, and Methods to Control Pollution Resulting from All Construction Activity. Columbia, Maryland. EPA 430/9-73-007. 234 pp.

University of Wisconsin. 1976. Non-Point Source Water Pollution, Part I. Non-Point Sources and Their Management. Water Resources Management Workshop. Madison, Wisconsin. 133 pp.

Maryland Dept. of Water Resources and Hittman Associates, Inc. 1972. Guidelines for Erosion and Sediment Control Planning and Implementation. EPA-R2-72-015. 229 pp.

*Abt Associates, Inc. Preventive Approaches to Stormwater Management. 1977. EPA 440/9-77-001. 207 pp.

The following Public Agencies have considerable expertise in dealing with erosion problems.

U.S. Geological Survey
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
USDA, Soil Conservation Service
FHA, HUD
Resource Conservation Districts
CalTrans

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*These references are particularly valuable and should definitely be consulted before making any important decisions regarding the application of this control measure.

REFERENCES

Chow, V. (ed.). 1964. Handbook of Applied Hydrology. McGraw-Hill. New York.

Tahoe Regional Planning Agency. 1977. Lake Tahoe Basin Water Quality Management Plan, Volume II, Handbook of Best Management Practices.

Tourbier, J., Westmacott, R. 1974. Water Resources Protection Measures in Land Development — A Handbook. University of Delaware Water Resources Center. Newark, Delaware. 237 pp.

Hittman Associates Inc. 1973. Processes, Procedures, and Methods to Control Pollution Resulting from All Construction Activity. Columbia, Maryland. EPA 430/9-73-007. 234 pp.

CONTROL MEASURE:	OBJECTIVE:
C-1 Treatment and storage of runoff	Reduce the amount of pollutants entering receiving waters

SUMMARY DESCRIPTION

The control measure consists of temporary storage with or without subsequent treatment to remove pollutants before discharge into receiving waters. The measure works by installing control devices in the storm sewer system to provide storage, constructing off-line storage such as ponds, tunnels and bags, and constructing treatment plants that can remove pollutants. This would reduce the amount of solids, organics, nutrients and metals entering receiving waters.

APPLICABILITY

This control measure deals with runoff after it has entered the storm sewer system. Once runoff has entered the system then these are the only techniques that can reduce the impact of runoff.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Storage and treatment of storm runoff would have pronounced effects throughout a community's entire public works program.

IMPLEMENTATION REQUIREMENTS

Technical aspects

To implement this control measure the necessary facilities, such as retention ponds, sewer flow control devices or treatment plants will have to be constructed. There will also be continuing operation and maintenance requirements.

Storage is probably the most cost-effective way of dealing with storm wastewater once it has entered the storm sewer system. Storage is best used in combination with existing treatment facilities.

Some of the storage facilities that have been tested are retention ponds, holding tanks, tunnels, underground/underwater tanks, and underwater bags.

The storm sealer system can also be used as storage for runoff. Various demonstrations have shown that optimal control theory can be used to maximize storage within the system through a series of remote control devices. It can also route the first runoff from a storm (which is the most polluted portion) to a treatment facility before storing the bulk of the flow in the storm sewer system. After collection, storm water is pumped back into the treatment facilities (after the peak storm flow has subsided).

Due to the transient and variable characteristics of storm water, traditional biological wastewater treatment facilities and processes do not perform well with storm water. Since most of the pollutants in storm water are associated with suspended matter, physical-chemical processes offer better performance. Table C-1 shows the efficiency of these processes for organics and suspended solids removal.

Regulators, swirl concentrators and other modern regulators provide both flow quantity and water quality control. The "swirl" action concentrates suspended solids and conveys that flow into a sanitary sewer. The relatively clear supernatant then flows on to the storm sewer.

Administrative requirements

Treatment and storage programs would have to be carefully designed, approved, financed and implemented. Depending on the type of programs, varying demand would be placed on administrative and public works staff.

POTENTIAL IMPACTS

Environmental impacts

Implementation of these types of control measures would cause some temporary environmental impacts during the construction phase (e.g., dust, noise, and air pollutant emissions, energy use). There could also be some impacts during the operational phase. Some would result in higher groundwater tables and/or introduce runoff-borne contaminants into groundwater aquifers. If not carefully managed, some retention facilities could develop adverse water quality conditions and could provide breeding sites for insects or have adverse impacts on aquatic life, public health and safety, and aesthetics.

Storage and treatment facilities could require considerable land areas, typically rather for down the watershed (possibly in wetland areas). Treatment facilities would demand considerable quantities of energy. The sludges and other solid residues removed from the stormwater would require proper disposal.

Socioeconomic impacts

The high cost of storage and treatment could put such a program in competition with other important public programs. On the other hand, implementation of these control measures would yield employment opportunities in both the public and private sectors (e.g., engineering, landscape design, construction, inspection, administration).

EVALUATION

The effectiveness of storage and treatment schemes depends primarily upon the portion of the total runoff dealt with and the efficiencies of the processes employed. At this stage of analysis, it is not possible to make meaningful predictions of effectiveness, except on a case-by-case basis.

Table C-1.

TREATMENT PROCESSES	ANNUALIZED COST FOR A CITY OF 100,000 ($)	REMOVAL EFFICIENCIES (%)			
		SS	BOD_L	N	PO_4
Swirl Concentrator	10,000	40	------	------	------
Sedimentation	88,000	45	erratic	------	------
Dissolved Air Flotation	184,000	75	50	18	81
Micro-Straining	21,000	70	10-50	------	------
Filtration	110,000	90	40	------	------
Contact Stabilization	278,000	92	83	50	50
Trickling Filters	340,000	65	65	small	small
Rotating Biological Contactors	216,000	60-95	50-95	40	50
Oxidation Lagoons	50,700	erratic	erratic	------	------
Aerated Lagoons	about 214,000	75-95	75-95	------	------
Physical-Chemical Systems	891,000	100	97	98	98

Source: Lager and Smith (1974)

EXAMPLES

San Francisco — Storage in sewer systems and stormwater treatment

Lodi, California — Retention ponds

REFERENCES

Field, R. Tafuri, A., Masters, H. 1977. Urban Runoff Pollution Control: Technology Overview. Edison, New Jersey. EPA-600/2-77-047. 91 pp.

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Leiser, C. 1974. Computer Management of a Combined Sewer System. Seattle METRO. EPA-670/2-74-022.

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HANDBOOK OF BEST MANAGEMENT PRACTICES

OCTOBER 1977

SURFACE RUNOFF MANAGEMENT PLAN
FOR THE
9 BAY AREA COUNTIES

COUNCIL OF BAY AREA RESOURCE CONSERVATION DISTRICT
5552 Clayton Road, Concord, Ca. 94521 (415) 682-2266

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HANDBOOK

OF

BEST MANAGEMENT PRACTICES

For The

9-Bay Area Counties

Prepared by:

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With Special Assistance, from:

USDA, Soil Conservation Service

The preparation of this report was financed through an area wide waste treatment management planning grant from the Environmental Protection Agency, Region IX, under the provisions of Section 208 of the Federal Water Pollution Act, as amended, and in cooperation and contract with the Association of Bay Area Governments.

COUNCIL OF BAY AREA RESOURCE CONSERVATION DISTRICTS
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APPENDICES

HOW TO USE THIS HANDBOOK

The following Control Measures are recommended as the Best Management Practices for water pollution control on agricultural land, open space and urban fringe areas. These measures are organized in thirteen categories identified with land use or hydrologic systems. Non-point source pollution problems can be identified and then related to one of the Control Measures by its land use or hydrologic relationship.

Conservation treatment is site specific. Agronomic, structural and managerial practices are used singly or in combination, depending on site requirements, to achieve pollution control.

Each Control Measure is composed of component Conservation Practices which are preventive techniques for solving erosion and resulting pollution problems. These are listed for each Control Measure under the heading, "Technical Aspects" and are summarized in Table 3 following the Control Measures. For each problem one or more of these Conservation Practices can be selected that best applies to the individual site conditions.

The Conservation Practices are defined on Pages 72 to 84. Estimates of costs for implementing these practices are given in the Tables on Pages 85 to 92.

Appendices contain a condensed version of Conservation Practice Standards developed by the U.S. Department of Agriculture, Soil Conservation Service, for use in the Resource Conservation District program. Copies of the complete standards and corresponding specification guides are available for review at Resource Conservation District offices serving each county.

MANAGEMENT PRACTICES FOR EROSION
and
SEDIMENT CONTROL

SAN FRANCISCO BAY REGION

This handbook contains guidelines which can be effectively used to control erosion and sediment, conserve water, improve and maintain infiltration and otherwise improve the quality of surface runoff waters from agricultural lands, open space, and urban fringe areas. It contains thirteen control measures supported by conservation practice standards which can be used to control existing problems and minimize the development of future erosion and sediment production problems. The conservation practice standards have been prepared to establish the minimum limit of technical excellence permissible in planning, design and construction or application, of these practices. Variations in soils, topography, or other physical features may require that they be strengthened when adapted for a specific area.

For success in controlling erosion and sedimentation, certain general principles need be followed. These are:

Use the land in accordance with its capabilities.
Leave the soil bare for the shortest time possible.
Reduce the velocity and control the flow of runoff.
Detain runoff at the source and trap sediment.
Release runoff safely down stream.

These principles are incorporated in the specifications for these control measures.

In the event of any variance between these practice standards and local ordinances, the criterian of the local ordinance will prevail.

Erosion control measures must be properly designed, installed and maintained if they are to accomplish their intended purpose. The practice standards contained in this handbook are guidelines and need to be supplemented by more detailed information when the practices are applied. Conditions related to the soil, topography and hydrologic conditions should be obtained in planning control measures for each site. Information on the detailed application of these practices as they apply to a specific locality is available from any of the 13 Resource Conservation Districts in the Bay region. More specific standards are available at the USDA, Soil Conservation Service offices serving the Resource Conservation Districts.

The needs for maintaining as much open space as possible and preserving prime and unique agricultural land cannot be overemphasized. One of the most important objectives for maintaining clean water is to have as much runoff as possible infilltrate safely through the soils. The preservation of these resources will not only enhance the water quality but provide a better environment and assurance of a continuing food supply, particularly of crops unique to the Bay Area climate.

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1977

CONSERVATION CONTROL MEASURES

	Control Measure	Objective
RCD-1	Conservation Cropping Systems	Protect the soil from erosion and improve or maintain soil conditions

SUMMARY DESCRIPTION

This measure includes cultural and management systems for cropland which will provide protection from sheet and rill erosion during the rainy season. Cropping practices a selected which will provide cover and increase the rate of infiltration of water into the surface, thereby reducing surface runoff. Cover crops are grown during periods when areas are bare and not protected from rainfall. Plant residues are maintained on the soil surface. Mulches are utilized when crop residues are inadequate to protect erodible sites, or to help establish plant cover. Plowing, preparing land, planting and cultivation is done on the contour where feasible to reduce erosion, control water and conserve energy.

APPLICABILITY

This measure applies to all cropland including orchards and vineyards, and certain recreation and wildlife sites. Usually the sloping lands and more erosive soils will require more complex treatment for controlling erosion. The combination of practices selected to apply this measure will depend on specific site conditions such as soils, topography and crops to be grown.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure would protect the land where conservation practices are applied and would benefit downstream properties. Runoff and sediment would be controlled. The amount of public funds needed for flood control and sediment removal would be reduced.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

Each site has to be planned in accordance with the soils, topography, climate and other factors. A combination of alternative land uses and practices are selected to fit conditions for the site. The combinations most suitable to the land user are then selected for application.

Components of complete conservation cropping systems may include but not be limited to:

Conservation Cropping System	Cover and Green Manure Crops
Contour Farming	Crop Residue Use
Contour Orchard and Other Fruit Areas	Minimum Tillage
	Mulching
	Stubble Mulching

For irrigated cropland, the control measure Conservation Irrigation System will apply.

Standards and specifications for the above practices are available for review at Resource Conservation District offices serving each county.

Administrative requirements:

This control measure would have to be implemented by the individual landowners. Technical assistance is available from Resource Conservation Districts for those landowners within the district. Implementation of this measure could increase the district workload and require administrative analysis and decisions as to the need for additional personnel.

Legal/political considerations:

A local ordinance for fire districts can be a contributor to sediment sources. Firebreaks may be required along property lines. Vegetation is removed, usually by disking. Erosion can be a problem where the firebreak is on a slope.

Fiscal considerations:

Costs for this control measure are normally the individual landowner's responsibility. There could be cost-sharing by the U. S. Department of Agriculture on some of the component practices needed to implement this measure.

POTENTIAL IMPACTS

Environmental impacts:

Conservation Cropping Systems include soil management practices that increase water penetration and reduce surface runoff. Minimum Tillage and Management of Plant Residues would reduce dust pollution as well as control erosion. Contour farming is often more scenic and conserves energy. Crop Residue Use avoids burning of crop residue, thereby eliminating smoke pollutants. Conservation Irrigation Systems are designed to meet crop needs and conserve water.

Socioeconomic impacts:

This measure would protect soil resources needed to produce food and fiber for future generations.

EVALUATION

Portion of the overall problem this measure would affect:

This measure would reduce sediment yields from cropland. The amount of land requiring treatment could vary considerably because of shifts in cropping patterns and farming methods.

Potential effectiveness on affected portion:

Soil erosion would be reduced and maintained within soil-loss tolerance rates.

Anticipated effectiveness in actual practice:

Soil erosion would be reduced and maintained within soil-loss tolerance rates.

COST CONSIDERATIONS

Costs can vary considerably for the different sites, depending on specific site conditions and crops to be grown. Size and shape of the fields and accessibility, have a significant bearing on the cost. Current costs of seed, fertilizers, equipment and labor, are included in EXAMPLES.

EXAMPLES

Cover and Green Manure Crops

Annual cover or green manure crops are generally used throughout most of the San Francisco Bay Area Counties for the purpose of maintaining soil tilth, fertility, and reduce water and soil losses. These two practices are notably effective in controlling erosion and sediment production from watersheds. Although the practice of growing ground covers and green manure crops are rather widely used on agricultural lands, where tree crops and row crops are grown, they can be used to stabilize small parcels of land in urbanizing areas. These practices are effective where vegetation is needed to stabilize soils that have been denuded by domestic livestock, e.g., horses, cattle, donkeys and sheep.

The proper time to seed these crops is early fall, between September 15 and October 30. Where irrigation systems are used, a selection of grasses and legumes should be drilled or sown following an application of water. Adapted cerial grains, annual grasses, and legumes are commonly used.

In order to affect quick growth and complete ground covers especially on sloping lands, an application of fertilizers should be made at the following rates: 150 lbs. per acre of ammonium sulfate if a legume is included in the seed mixture. All legume seeds should be inocculated to assure proper performance of growth.

Proper utilization of these crops begin early in the crop season, usually around March 15, by discing the covers down. Thus, the plants are incorporated into the soil as green manure and no longer compete for soil moisture and nutrients. However, they can be partially grazed by livestock and adequate quantities of residue left to protect soils where needed.

As an example, a single seeding of barley for a green manure or cover crop would under most farming conditions cost approximately:

Barley seeded at 70 lbs/acre, $10.00/cwt	$ 7.00
Seeding by drill or broadcast	5.00
Land preparation, 2 discings, @ $4.00	8.00
Fertilizer, 250 lbs/acre (ammonium phosphate,.05/lb)	12.50
COST PER ACRE =	$32.50

This represents costs when done by the owner with his own equipment; where the seeding is done by a contractor, the costs of equipment use and on and off move charges must be included.

The size of the job will have a bearing on the costs.

Crop Residue Use

Cost Considerations: The steps taken and costs incurred to reduce the residues produced are usually integrated into the overall cultural program of the farm. Typical expenditures related to this practice are as follows:

Disking (2 times) @ $5.00/acre	$10.00
Fertilizer, ammonium phosphate, 250#/ac. @ .05/lb.	$12.50

Note: Plowing - if complete reduction of residues is necessary for row cropping - $10.00/acre.

Example:

The incorporation of crop residues back into the soil, after harvesting, is an important part of a cropping system.

By retaining the organic residues on/or near the surface, soil tilth is improved (makes it more easily worked and irrigated). This practice helps maintain the soil fertility thus keeping the crops vigorous and producing better yields. This trashy residue helps reduce soil and water losses during the rainy season by holding the soils in place and allowing more water to enter the soil.

However, there is a loss of nitrogen used in the breakdown of these residues. Fertilizer is usually added at 20-50 lbs. Nitrogen (depending on kind and amount of residue) per acre to offset this tie-up.

REFERENCES

1. Soil Conservation Service, "Field Office Technical Guide," U. S. Department of Agriculture, District Field Office (unpublished).

2. Soil Conservation Service, "Guide for Erosion and Sediment Control in California, 1975," United States Department of Agriculture, Davis, California

	Control Measure	Objective
RCD-2	Conservation Irrigation System	To reduce the pollutants carried by irrigation waters from irrigated land

SUMMARY DESCRIPTION

This control measure consists of installing improved conservation irrigation systems either as a new system or to replace an irrigation system which contributes eroded material and other pollutants by excessive irrigation stream flow.

Water management of irrigation water should be utilized to keep irrigation water under control without excessive waste water and erosion. The irrigation system must be designed to meet the needs of the site in order to obtain optimum irrigation for crop needs with minimum waste and pollution. Irrigation water conveyance consists of lined canals and ditches or pipelines to supply water to the irrigation application system. Systems may include sprinklers, drip systems and surface or subsurface systems. Tailwater systems collect excess or waste water for re-use or disposal to a safe location.

Water management consists of the control of irrigation water to apply only that water required by the crop with minimum excess or waste water and minimum erosion. Irrigation may be required on construction sites to establish a vegetative cover and to maintain dust control.

APPLICABILITY

Conservation irrigation systems are applicable to all agricultural land, construction sites, and other areas that are suitable for irrigation, where irrigation is required for crop growth and where a water supply of suitable quality and quantity exists. Surface and subsurface irrigation are adaptable to the more level areas. Sprinkler irrigation is adaptable to most crops on sloping land as well as level land. Drip irrigation can be used for most orchard crops and row crops, gardens and flower areas, and where water supply is limited and other methods may cause excessive erosion.

Tailwater systems are used to collect excess water from surface systems. Lined canals and ditches or pipelines should be installed on sites where erosion occurs in unlined canals and ditches.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure would reduce sedimentation and other pollution in adjacent downstream areas where improper irrigation water application results in excess waste water and erosion. This would result in reduced cleanup of sediments by governmental agencies and landowners.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

This control measure would have to be designed and installed to meet individual site conditions.
Component standards for this control measure may include but are not limited to:

- Irrigation System, Drip
- Irrigation System, Sprinkler
- Irrigation System, Surface & Subsurface
- Irrigation System, Tailwater Recovery
- Irrigation Water Management
- Irrigation Ditch and Canal Lining
- Irrigation Pipeline

Standards and specification guides for the above practices are available fo review at Resource Conservation District offices serving each county.

Administrative requirements:

This control measure would have to be implemented by the individual landowner or group of landowners. Technical assistance is available from Resource Conservatic Districts for those landowners within the district. Implementation of this measure could increase the district workload and require administrative analysis and decisic as to the need for additional personnel. In some cases, the landowner may have to make arrangements with organized irrigation districts. Construction site plans would require additional governmental public works staffing for review of plans.

Legal/political considerations:

Water rights must be resolved with the State Of California Water Rights Board, depending on the source of the irrigation water. Landowners and developers must comply with any legal requirements of organized irrigation or water districts, where irrigation water is obtained from such district. Where earthmoving or grading are involved, such work must comply with requirements of grading ordinances. Other local ordinances may also be applicable.

Fiscal considerations:

Costs for this control measure are normally the responsibility of the individual landowner or group of landowners. Costs for irrigation on construction sites are normally the responsibility of the developer and are included in development costs

POTENTIAL IMPACTS

Environmental impacts:

The environmental impact of dust, air pollution and construction noise would be temporary only during construction where earthmoving or other construction activity occurs. Dust and air pollution could be partially controlled by watering of the construction site.

Improved irrigation systems would present a more pleasing appearance where exposed to public view.

Socioeconomic impacts:

Short-term employment opportunity would be available during construction.

EVALUATION

Portion of the overall problem this measure would affect:

Control of excess irrigation water and erosion will deal only with the particular area involved.

Potential effectiveness on affected portion:

This control measure could reduce virtually all waste water runoff and erosion from the specific area to be irrigated.

Anticipated effectiveness in actual practice:

In actual practice, this control measure can be expected to reduce virtually all waste water and erosion from the irrigated area, thereby removing the irrigated area from the overall problem as a pollution source.

COST CONSIDERATIONS

Costs of a conservation irrigation system would vary considerably from site to site, depending on such factors as site conditions, area and shape of field units, terrain, soil types, access to the site and haul distance for materials and equipment to be used. Costs are also variable depending on the type of irrigation system to be installed.

One source of irrigation cost information indicates the following capital cost per acre for the various irrigation system types:

Sprinkler Systems	
Portable	$400 - 600/acre
Wheel Roll	400 - 600
Solid Set	700 - 1,200
Center Pivot	700 - 1,000
Boom (Giant)	600 - 700

Surface Flood Systems	
Graded Border	$500 - 600
Level Border	500 - 600
Furrow	400 - 500
Drip Systems	500 - 1,200

Source: Interagency Agricultural Drought Information Task Force, "Selecting an Irrigation System - Should You Change?" Compiled by representatives of the Soil Conservation Service, University of California Cooperative Extensive Service, Bureau of Reclamation, Irrigation and Resource Conservation District
S and irrigation equipment representatives or irrigation consultants, 1976.

Other sources of cost information may vary considerably, however, these costs will provide a reasonable estimate of a well-engineered irrigation system.

EXAMPLES

Irrigation System, Tailwater Recovery - Alameda County

The system consists of an earth sump with a capacity of approximately 166,000 gallons which collects tailwater from a 157-acre surface irrigation system by use of a pickup ditch. A 20-horsepower pump at a concrete pump well, pumps the tailwater from the sump, through 2,459 lineal feet of 12-inch PVC pipe, to the head ditch for 90 acres; through 2,137 lineal feet of 10-inch PVC pipe for the remaining 67 acres at the upper end of the system. The tailwater, assumed to be about 20% of the applied water, is thereby re-used by mixing with additional water from a canal.

Tailwater is re-used in this system and is not permitted to waste onto the adjacent county road right-of-way along with any sediment from the fields. Proper Irrigation Water Management Practices control the water flow within the system and eliminates virtually all erosion and sedimentation from the fields, as well as conserving water.

REFERENCES

1. Soil Conservation Service, "National Engineering Handbook," Section 2, Engineering Practice Standards," U. S. Department of Agriculture, Washington, D.C., April 1971.

2. Soil Conservation Service, "Field Office Technical Guide," U. S. Department of Agriculture, District Field Offices. (unpublished)

3. Interagency Agricultural Drought Information Task Force, "Selecting an Irrigation System - Should You Change?" 1976

	Control Measure	Objective
RCD-3	Control Erosion from Construction Sites	To control runoff and reduce the amount of sediments and other pollutants carried by runoff

SUMMARY DESCRIPTION

This control measure consists of structural, vegetative, and other soil stabilization methods to control runoff and reduce the volume of sediment and other pollutants carried by runoff from construction sites. Such sites present a high erosion hazard when grading and other construction activity starts. This becomes highly important, since much of the residential development is now being done on sloping to steep hilly land.

This measure is applicable to the development of residential and commercial areas, highway construction, industrial areas, flood control, water development and other utility projects and includes both private and public construction. Plans for runoff and erosion control of construction sites should be developed in the early planning phase and should be incorporated into final plans prior to approval and issuance of the necessary construction permits by the responsible government agencies. In developing the control plan, each method of control should be scheduled so that work by the contractor can proceed in an orderly manner. Construction scheduling should be planned so that exposed excavated and graded areas are kept to a minimum during the winter rainy season.

The specific methods of control should be determined after careful site evaluation, and will depend on topography, geology, erosion potential of the exposed soils, infiltration capacity of the soil profile, existing vegetative and wooded cover in the area, hydrology and time period of exposure of the soil, to name a few conditions. Types of control may include vegetation of exposed areas, diversions and ditches, debris basins, sediment traps, mulching, chemical soil treatment and stabilization by netting, fiberglass roving or other commercial products. Controls may be temporary or permanent depending on whether they are still needed after construction is completed. The construction contract should include permanent controls where grading and other earthwork areas are expected to still be exposed after completion of construction. Permanent controls should be installed to be pleasing in appearance since they will become a permanent part of the landscape.

In addition to construction of erosion control measures, the construction contract should provide for maintenance measures by the contractor, to insure proper functioning of the control measures while the contract is in force. Maintenance of permanent control measures should be continued by the developer or others after completion of the construction contract.

APPLICABILITY

This control measure is applicable to all construction sites where erosion will be a problem during or after construction. This measure will be more applicable to development in hilly areas where erosion hazards are normally more severe depending on stability of the soil and rainfall patterns. Where debris basins are involved, suitable sites must be available either as on-channel or off-channel storage of sediment or other pollutants without creating hazards to adjacent or downstream areas.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure would benefit areas downstream of the construction site by control of runoff and reduction or elimination of sediment which would otherwise occur from the development. Reduction of sediment would also benefit downstream receiving waters. By reducing sediment deposition, the cost of removal of sediment by governmental and private agencies will be reduced.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

This control measure will require on-site investigation, geology and soil mechanics study, hydrology, extent of exposed soils, erodibility of exposed soils, adaptability of various vegetation types and complete plans for control to be prepared and included with the construction plans and contract. Provision must be made for maintenance to insure proper functioning for the duration of the construction contract and after completion of the contract as may be required. Component standards for this control measure may include but are not limited to:

- Access Road
- Cover and Green Manure Crop
- Critical Area Planting
- Debris Basin
- Diversion
- Grade Stabilization Structure
- Grassed Waterway or Outlet
- Heavy Use Area Protection
- Hillside Ditch
- Irrigation System, Sprinkler
- Irrigation Water Conveyance, Pipeline
- Irrigation Water Management
- Land Smoothing
- Lined Waterway or Outlet
- Mulching
- Open Channel
- Pond
- Pond Sealing or Lining
- Stream Bank Protection
- Stream Channel Stabilization
- Tree Planting

Standards and specification guides for these practices are available for review at Resource Conservation District offices serving each county.

Administrative requirements:

This control measure would have to be reviewed and approved by planning and public works staffs of responsible public agencies prior to issuance of a construction permit. Staffing of planning and public work agencies would have to be adequate to perform this added responsibility. Planning agency staffs should preferably include a staff member with a knowledge of soils and erosion control methods. For construction by governmental agencies, it is expected that such agencies will have staff members capable of design and review of their erosion control plans.

Resource Conservation Districts can provide technical guidance on erosion control methods for construction sites.

Legal/political considerations:

Developers must comply with rules and ordinances of government agencies. This is usually done by issuance of a building or construction permit after review and approval of plans and specifications, and prior to the start of construction. Compliance with specific state or federal regulations may be required. California's version of the National Environmental Protection Act (EPA) requires counties to make environmental assessments before issuing building permits to private groups concerned with land development which could include erosion control on construction sites. Regional [illegible]

Quality Control Boards would have controls where water quality criteria are concerned. It is expected that developers would be familiar with legal requirements concerning easements for drainage and run-off channels.

Fiscal consideration:

Costs for this control measure would be the responsibility of the developers, whether a private development or governmental development. Costs on private development would no doubt be added to project costs and passed on in sale of the individual units or in rentals. Non-private development would be borne by public funds

POTENTIAL IMPACTS

Environmental impacts:

Implementation of this control measure would cause dust, air pollution and construction noise which would be temporary during construction. Dust could be controlled by watering. Further control of dust could be obtained by erosion control measures on open areas by practices such as vegetation or other soil stabilization methods. A favorable environmental effect could be obtained after construction by planting of vegetation to include grass, trees and shrubbery.

Socioeconomic impacts:

Implementation of this control measure would offer temporary employment opportunity during the planning and construction period in both private and public agencies. On projects having a close cost benefit ratio, it is possible that the added cost of erosion control methods, if extensive, could increase the costs to the extent that the project would be unfeasible and cancelled, thereby eliminating some potential employment opportunity.

EVALUATION

Portion of the overall problem this measure would affect:

This control measure would control runoff and erosion with resulting sediment discharge only from the area being developed. Where measures are to be permanent, benefits would be obtained by the control of runoff and erosion after construction is completed. Construction of new facilities is estimated to use up more than one million acres of land annually at the present time in the United States. It is not known what portion of this acreage is in the Bay Area counties, however this area's acreage must be significant when the amount of construction in the Bay Area is considered.

Potential effectiveness on affected portion:

This control measure could potentially eliminate the greater portion of soil loss from the areas being controlled. Some research work indicates that the effectiveness of ground cover on erosion loss at construction sites as 90% and greater.

Anticipated effectiveness in actual practice:

In actual practice this measure can be expected to eliminate the greater portion of sediments from the controlled area, thereby removing this area as a serious problem. Adequate maintenance of this measure is required to insure satisfactory erosion control.

COST CONSIDERATIONS

Costs for this control measure would vary considerably depending on site conditions and the type of controls to be installed. Various methods of control are included in the following control measures:

- Conservation Irrigation System
- Control Roadside Erosion
- Critical Area Treatment
- Diversion and Ditches
- Grade Stabilization Structures
- Runoff and Sediment Control, Ponds and Basins
- Streambank and Channel Protection and Stabilization
- Watershed, Wildlife and Recreation Land Improvement

Unit costs are listed in the Table of Installation Costs for Major Conservation Practices.

EXAMPLES

Actual examples of erosion control from construction sites were not available. It appears that there is very little, if any, such control work being done on construction sites.

REFERENCES

1. Soil Conservation Service, "Guide for Erosion and Sediment Control in California", U. S. Department of Agriculture, Davis, California, January 1975.

2. Hittman Associates, Inc., "Processes, Procedures, and Methods to Control Pollution Resulting from all Construction Activity", U. S. Environmental Protection Agency, Washington, D.C., EPA-430/9-73-007, October 1973.

3. Davey, William B., "Conservation Districts, and 208 Water Management", National Association of Conservation Districts, U. S. Environmental Protection Agency, 1977.

4. Soil Conservation Service, "Controlling Erosion on Construction Sites", Agriculture Information Bulletin 347, U. S. Department of Agriculture, December 1970.

5. U. S. Environmental Protection Agency, "Comparative Costs of Erosion and Sediment Control, Construction Activities", Washington, D.C., EPA-430/9-73-016, July 1973.

6. Soil Conservation Service, "National Engineering Handbook, Section 2, Engineering Practice Standards", U. S. Department of Agriculture, Washington, D.C., April 197[illegible].

Table 1

EFFECTIVENESS OF GROUND COVER ON EROSION LOSS AT CONSTRUCTION SITES

Kinds of Ground Cover	Soil Loss Reduction Related to Bare Surfaces (Percent Effectiveness)
*Seedlings	
Permanent Grasses	99
Ryegrass (Perennial)	95
Ryegrass (Annual)	90
Small Grain	95
Millet & Sudangrass	95
Field Bromegrass	97
Grass Sod	99
Hay (2 tons per acre)	98
Small Grain Straw (2 tons per acre)	98
Corn Residues (4 tons per acre)	98
Wood Chips (6 tons per acre)	94
**Wood Cellulose Fiber (1-3/4 tons per acre)	90
**Fiberglass (1,000 lbs. per acre)	95
**Asphalt Emulsion (125 gallons per acre)	98

*Based on full established stand
** Experimental - not fully validated

Reference: U. S. Environmental Protection Agency, "Comparative Costs of Erosion and Sediment Control, Construction Activities", EPA-430/9-73-016, July 1973 (From County of Fairfax, Virginia, Erosion-Siltation Control Handbook, August 1972).

	Control Measure	Objective
RCD-4	Control Roadside Erosion	To control runoff and reduce the amount of pollutants from roadside areas

SUMMARY DESCRIPTION

This control measure consists of the control of erosion along roadway rights-of-way by installation of structures, vegetation and other means of stabilizing the soil. Road construction in recent years has included various methods of soil stabilization to control runoff and erosion and to maintain proper drainage. The problem is the many miles of older roads with poor drainage, steep erosive slopes and road ditches with erosive velocities. There is also some problem on new roads when temporary soil stabilization is required during the construction period.

Erosion control methods would include: reducing steep side slopes to a stable slope by either cutting back the slope or stabilizing by structural means such as retaining walls; fertilizing and vegetating those slopes where it is impossible to stabilize by reducing the slope; constructing interceptor ditches or diversions at the top of side slopes to carry runoff away from the slope to a stable discharge point; stabilizing road ditches by either structural controls such as check dams or by other means such as vegetation, fiberglass roving, netting or other manufactured products; and by proper drains involving the use of well designed inlet and outlet boxes, chutes and other mechanical controls. The purpose is to control all runoff along roadsides with minimum erosion until it is safely discharged to some stable channel or stream.

APPLICABILITY

This control measure is applicable to all existing roadway rights-of-way where a runoff and erosion problem exists. This measure can also apply to new roadway construction during the construction stage. Controls should be included in the design of new roads prior to construction.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure would benefit public programs by reducing the maintenance of the roadway rights-of-way to be controlled; reducing runoff and sediment damages downstream, thereby reducing maintenance; and by improvement of the aesthetic appearance of the roadway rights-of-way. Reduction of sediment discharge into downstream areas will be of definite benefit to the water quality.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

There are many methods of stabilizing roadside slopes, some of which create stability itself, and others providing temporary stability until vegetative cover is established. The method selected for a specific site would depend on site conditions such as geology, soil type, topography, hydrologic analysis, etc. Specific methods could include diversions above the slope, vegetation such as grass and shrubs or trees, structural controls, and stabilization products such as mulches, netting and chemical soil binders.

Component standards for this control measure may include but are not limited to:

- Critical Area Planting
- Diversion
- Fencing
- Grade Stabilization Structure
- Grassed Waterway or Outlet
- Hillside Ditch
- Irrigation System, Drip
- Irrigation System, Sprinkler
- Irrigation Water Conveyance - Pipeline
- Lined Waterway or Outlet
- Mulching
- Tree Planting

Standards and specification guides for the above practices are available for review at Resource Conservation District offices serving each county.

Administrative requirements:

Implementation of this control measure on public roads would place additional demand on administrative and public works staffs of cities and counties. Technical assistance on runoff and erosion problems along private farm roads is available from Resource Conservation Districts for those landowners within the district. Implementation of this measure could increase the district workload and require administrative analysis and decision as to the need for additional personnel.

Legal/political considerations:

This control measure would involve the public works departments of cities and counties with some involvement possible by the state. The landowners would be responsible for this measure on private property.

Rights-of-way would be a problem in many cases, since they are not of sufficient width to permit sloping back of the slopes. Additional rights-of-way would be required. Rights-of-way for the safe disposal of roadway drainage waters away from the road must be considered and may present legal problems.

Fiscal considerations:

This control measure would be financed from local funds with possible financial assistance from state and federal funds. Landowners would be responsible for financing on private property with possible cost sharing from the United States Department of Agriculture.

In many cases, additional rights-of-way would have to be purchased to provide adequate area for cutting back roadway slopes.

POTENTIAL IMPACTS

Environmental impacts:

The environmental impact of implementing this erosion control measure, such as dust, air pollution and construction noise would be temporary only during construction. Dust could be controlled by watering. Runoff water quality would be improved by the reduction or elimination of sediments normally carried by the runoff. The aesthetic appearance of the roadsides would be vastly improved.

Socioeconomic impacts:

Implementation of this control measure would offer employment opportunities during the construction period. The adverse effect on employment opportunity would be the reduction in maintenance work due to eliminating roadside sediment cleanup in downstream areas. This might be offset by the use of maintenance forces in stabilizing the roadside slopes and ditches to be controlled.

EVALUATION

Portion of the overall problem this measure would affect:

This control measure would reduce or eliminate sediment accumulation only from those areas to be controlled. It is not possible to estimate the effect on the overall problem since the extent of the overall problem is not known at this time. It is estimated that roads occupy approximately 140,000 acres in the 9 Bay Area counties. It is not known what portion of the overall problem is in need of improvement for sediment control purposes.

Potential effectiveness on affected portion:

This control measure could potentially eliminate virtually all sediments from the area being stabilized.

Anticipated effectiveness in actual practice:

This control measure can be very effective in eliminating soil erosion and resulting sedimentation on the specific area under control, however some damage may occur in the event of unusually heavy storms.

COST CONSIDERATIONS

Costs for roadside erosion control practices can vary considerably, depending on site conditions, climate, extent of the work and type of problems. It has been estimated that erosion control costs would be approximately $10,000 to $15,000 per mile for a highway cost of one million dollars per mile, or 1 to 1-1/2% of the highway costs.

A study by the California Department of Transportation in 1975-76 demonstrated the use of fiberglass roving with vegetation for erosion control in drainage ditches. Three sites in the State were treated, which had various soil types and different climatic conditions. One site was in Sonoma County approximately two miles northwest of Sebastopol on State Highway 116. The other two sites were in other parts of the State. The fiberglass roving with vegetation was effective in reducing erosion at all three locations. Grasses planted prior to treatment emerged through the fiberglass mat with little or no difficulty. Treatment costs including shaping, fertilizing, seeding and installing the fiberglass roving, varied from $1.13 to $2.27 per square yard for areas of 363 to 786 square yards. The cost for the Sonoma County site of 402 square yards was $2.27 per square yard, the highest unit cost of the three trial sites. The cost per square yard is expected to be considerably less where larger ditch areas are treated.

Source: Nolan, M.E., Hatano, M.M., Howell, R.B., Shirley, E.C., "Control of Ditch Erosion Using Fiberglass Roving" California Department of Transportation, Sacramento, California, CA-DOT-TL-7225-1-6-41, July 1976.

EXAMPLES

There are numerous examples of roadside erosion control to be seen in the Bay Area Region. Excellent examples can be observed, mainly along the interstate freeways, state highways and many of the recently constructed or improved local roads. Controls usually consist of vegetated slope protection established by various methods including hydroseeding, straw mulch and seeding with netting and other means of establishment. Sprinkler irrigation is normally required to establish the vegetation with many slopes having permanent irrigation systems. In some cases retaining walls have been constructed to contain the slopes, wholly or in part. Where slope drainage problems have occurred or are expected to occur, horizontal drains or flexible slope drains have been installed. Diversions or hillside ditches have been constructed above and within long slopes with some ditches being paved and others unpaved where soil materials were erosion-resistant. Some roadside drainage waterways have been stabilized with stone or gravel protection or low head grade stabilization structures.

Roadside erosion control practices often serve a multiple purpose where vegetation is established. Plants for erosion control will provide landscaping benefits for highway beautification and in some cases may provide protective cover for wildlife. An example of protective cover with a pleasing appearance is the rather wide use of ice plant along the freeways.

REFERENCES

1. Soil Conservation Service, "National Engineering Handbook, Section 2, Engineering Practice Standards," U.S. Department of Agriculture, Washington, D.C., April 1971.

2. Soil Conservation Service, "Field Office Technical Guide," U.S. Department of Agriculture, District Field Office. (unpublished)

3. Soil Conservation Service, "A Guide to Planting for Erosion Control and Beautification (Rev. January 1970)," U.S. Department of Agriculture, Washington, D.C.

4. U.S. Environmental Protection Agency, "Control of Erosion and Sediment Deposition from Construction of Highways and Land Development," Washington D. C., September 1971.

5. California Department of Public Works, Division of Highways, "Temporary Erosion Control," Sacramento, California, May 1970.

6. Nolan, M.E., Hatano, M.M., Howell, R.B., Shirley, E.C., "Control of Ditch Erosion Using Fiberglass Roving," California Department of Transportation, Sacramento, California, CA-DOT-TL-7225-1-6-41, July 1976.

	Control Measure	Objective
RCD-5	Critical Area Treatment	Stabilize eroded or potentially erodible areas to reduce damage from runoff and sediments

SUMMARY DESCRIPTION

This measure consists of planting vegetation such as trees, vines, grasses or legumes on areas that have critical erosion problems. Vegetation is difficult to establish on these areas with the usual seeding and planting methods. Special plants and site treatment are needed to establish vegetation.

Landshaping, mechanical controls, mulches, irrigation and fertilizers are often needed to establish selected planting materials.

APPLICABILITY

This Control Measure is applicable on sediment producing highly erodible areas, such as construction sites, dams, dikes, mine spoil, cuts, fills, surface mined areas and denuded or gullied areas.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

The treatment of critical areas would reduce downstream sediment loads and thereby lessen the amount of public funds needed for cleaning and hauling away the sediments.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

This measure requires detailed "on-site" investigation to obtain information to plan suitable methods of treatment. Plans should include selection of methods for erosion control, how control measures will be established and needs for maintenance.

Components of Critical Area Treatment may include but not be limited to:

- Critical Area Planting
- Debris Basin
- Diversion
- Fencing
- Hillside Ditch
- Irrigation Systems, Drip
- Irrigation Systems, Sprinkler
- Land Smoothing
- Livestock Exclusion
- Mulching

Standards for the above practices are available for review at Resource Conservation District offices serving each county.

Administrative requirements:

This control measure would have to be implemented by the landowner, developer and public agencies. Technical assistance is available from Resource Conservation Districts for those landowners within the district. Implementation of this measure could increase the district workload and require administrative analysis and decisions as to the need for additional personnel. Additional local public works staff may be needed for implementing public or developer's plans.

Legal/political considerations:

Access and rights-of-way may need to be considered to adequately apply some of the practices required to fully implement this measure. Some local governments have ordinances regarding excavation and grading that need to be observed where this is part of the planned treatment.

Fiscal considerations:

Costs for this control measure are normally the landowners responsibility on agricultural lands with possible cost sharing by the United States Department of Agriculture. Costs for construction sites are normally the responsibility of the developer. Governmental agencies bear the costs where public improvements are involved.

POTENTIAL IMPACTS

Environmental impacts:

This measure would reduce damage from sediment and runoff to downstream areas. It would enhance natural beauty and improve wildlife habitat. Some sites might have temporary dust pollution and construction noise while installing mechanical practices included in this measure.

Socioeconomic impacts:

Implementation of this measure would give some employment opportunities related to construction activities, installation of erosion control measures and maintenance.

EVALUATION

Portion of the overall problem this measure would affect:

Critical areas are high sediment producers. Their stabilization is necessary in the overall solution to sediment controls within a watershed. It is not possible to estimate the total extent of critical areas needing treatment in the Bay Area.

Potential effectiveness on affected portion:

The sites where this measure applies are usually small enough so that it is feasible to adequately treat the total area. Sediment losses can be reduced to a negligible amount.

Anticipated effectiveness in actual practice:

In actual practice each treated area would be removed from the overall problem of reducing downstream sedimentation.

COST CONSIDERATIONS

Costs can vary for the different sites depending on specific conditions, including soils, topography, effects of mechanical disturbances on the site and accessibility. Table 2 illustrates some of the costs that might be expected for some of the erosion control methods that would be used in implementing this measure.

EXAMPLES

Napa County

The Control Measure for this problem consisted of the following component practices: Critical Area Planting, Diversion, Fencing and Livestock Exclusion.

The problem was a large active gully with two branches eroding back into pasture lands. The drainage area was small, however the soil is highly erodible and the pasture is heavily grazed thereby increasing the erosion problem.

Control consisted of constructing a diversion around the head of the gully, collecting all runoff and draining from each end toward the center section. A pipe outlet consisting of a concrete headwall and pipe drop structure lowered the runoff to the gully bottom which was reasonably stable. The gully area was planted to shrubs and trees and completely fenced to keep out the livestock.

After three years, the gully is inactive and is fairly well stabilized with vegetation including grass moving into it from the top of the banks.

REFERENCES

1. Kay, Burgess L., "Hydroseeding, Straw and Chemicals for Erosion Control, Agronomy Progress Report No. 77," June 1976, Agricultural Experiment Station, Cooperative Extension Service, Universityof California, Davis, California

2. Soil Conservation Service, "Guide for Erosion and Sediment Control, 1975," United States Department of Agriculture, Davis California.

3. Soil Conservation Service, "Field Office Technical Guide," United States Department of Agriculture, District Field Office (unpublished).

4. Edmunson, George C., Highway Research Report - Plant Materials Study, 1976. United States Department of Agriculture, Soil Conservation Service, Davis, California, in cooperation with U. S. Department of Transportation, Federal Highway Administration, USDA Soil Conservation Service, Plant Materials Center.

5. Soil Conservation Service, "A Guide to Planting for Erosion Control and Beautification (Rev. January 1970)," United States Department of Agriculture, Davis, California.

SUMMARY OF METHODS AND COSTS OF COMMON EROSION-CONTROL PRACTICES

Treatment	Comments	Approx. cost per Acre $*
1. Seed and fertilizer broadcast on the surface, no soil coverage or mulch.	Inexpensive and fast. Most effective on rough seedbeds with minimum slope and erodability where seed will cover naturally with soil. Suitable for remote or critical areas where machinery cannot be taken.	250
2. Hydroseeding or hydromulching (seed + fertilizer) with 500 lb. wood fiber, 1,500 gal. water/ 3 acres.	Similar effectiveness to broadcasting seed and fertilizer. Not enough fiber to hold seed in place or produce a mulch effect. Seed distribution would be improved by increased volume of water.	250
3. Seed and fertilizer broadcast and covered with soil (raking or dragging a chain, etc.).	Does not require special equipment. Generally a very effective treatment. Labor cost is high on areas not accessible by equipment.	320
4. Hydromuching with 1,500 lb/acre wood fiber (plus seed and fertilizer).	Most common hydromulch mix in California. Advantages include holding seed and fertilizer in place on steep and smooth slopes where there may not be an alternative method. Only a minimal mulch effect. Cost is much higher than 2.	425-520
5. Hydromulching with 1,500 lb. woodfiber plus an organic glue: Ecology Control, Terratack III etc. plus seed and fertilizer.	The addition of an organic glue will sometimes improve fiber holding and germination. Does not increase labor or machinery cost.	550-650
6. Hydromulching with 2,000-3,000 lb/acre wood fiber plus seed and fertilizer.	Produce a true mulch effect and some erosion protection. Commonly better results than 1,000 lb. fiber or fiber plus glue.	530-750
7. Seed and fertilizer broadcast and covered with soil as in 3 above, but followed with hydromulch of wood fiber at 2,000-3,000 lb/acre.	Very effective, combines advantages of seed coverage and mulching.	680-865

All of the above treatments offer only minimal protection from the impact of raindrops and water flowing over the surface, but are all weed free.

. Straw or hay broadcast with straw blower on the surface at 3,000 lb/acre and tacked down (asphalt emulsion, Terra-tack II, etc.). Seed and fertilizer broadcast with hydroseeder or by hand.	Common elsewhere in U.S. Very effective as energy absorber, mulch; and straw forms small dams to hold some soil. May be weedy depending on straw sources. Not for cut slopes steeper than 2:1. Cost would increase significantly if slopes over 50 feet from access, or application is uphill.	650
. Straw broadcast 4,000 lb/acre rolled to incorporate (punched) another 4,000 lb. straw broadcast and rolled, seeded and fertilized. Seed and fertilizer broadcast with hydroseeder or by hand.	Common on difficult fill slopes in California. Very effective. Not possible on most cut slopes. Very weedy. Cost would increase significantly if slopes over 50 feet from access.	877-1070
. Roll-out mats (jute, excelsior, etc.). Held in place with wire staples. Seed and fertilize as in 1 or 2.	Some are a good mulch, weed free, adapted to small areas. Can be installed any season, cuts or fills. Unsightly. Difficult to install on rocky soils.	2400-2700
. Polyethyone sheets. (4 mil) Seed and fertilize as in 1 or 2, use clear plastic, black if no seed is used.	Usefulfor temporary control. Can be installed any season. Unsightly, wind is a problem in installation and maintenance. May be difficult to establish plants.	2400-2700
. Seed and fertilizer broadcast, or hydromulched with fiber, (treatment 2 or 4), followed by erosion control chemical such as polyvinyl acetate at 6:1 dilution (6 parts water) at 1,000 lb. solid/acre (approx. 200 gal. PVA).	Very expensive, but will hold soil and seed in some very difficult conditions. May restrict penetration of water into soil. Will not cure below 55° F. Not effective on soils which crack. Will not support animal or vehicle traffic.	1070-1370

Assumes seed plus fertilizer $150.00, fiber $150/ton, Ecology Control $1.25/lb., PVA $3.00/gal. 1,500 gal hydroseeder with 2 man crew $55.00/hr., labor $13/hr., straw mulcher with 4 man crew $64/hr (applies 2 T/hr.), and markup of 30% for overhead (including equipment depreciation), and profit, straw $50/T. Cost figures were derived from conversations with contractors, and by review of recent Caltrans contracts.

ference: "Mulches for Erosion Control and Plant Establishment", Burgess L. Kay, [illegible] Seeding Specialist, Dept. of Agronomy and Range Science, U.C./Davis 95616

	Control Measure	Objective
RCD-6	Diversions and Ditches	Divert runoff away from eroding and critical areas to reduce accumulation of sediment and other pollutants

SUMMARY DESCRIPTION

This control measure consists of constructing diversions and hillside ditches to collect and divert runoff from areas presently eroding or subject to erosion and to dispose of such runoff to non-erosive sites. Such diversions would eliminate or reduce the amount of sediment or other pollutants which could be picked up by runoff and thereby reduce the adverse impact of pollution on receiving waters or downstream land areas.

A diversion consists of a designed channel with a supporting ridge on the lower side, constructed with a designed grade across the slope. A hillside ditch consists of a channel with a supporting ridge on the lower side constructed across the slope at definite vertical intervals and gradient depending on the slope of the land. Adequate outlets must be provided to dispose of runoff safely at some stable point without creating an erosion hazard. Suitable outlets may be a grassed waterway, paved or vegetated area, grade stabilization structure or other stable area where erosion will not occur.

APPLICABILITY

This control measure applies to sites where (1) runoff from higher lying areas is damaging cropland, pastureland, farmsteads, conservation practices, or urban areas; (2) surface and shallow subsurface flow is damaging sloping upland; (3) required as part of a pollution abatement system, waste management system, or to control runoff and erosion on urban or developing areas and construction sites. Diversions are not usually applicable below high sediment producing areas unless land treatment practices or structural measures to reduce sediment pollution are installed with or before the installation of the diversion measures.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

The diversion structures constructed by this measure may also serve a valuable purpose in protecting properties downstream and providing flood control benefits. By reducing or eliminating sediment deposition in downstream areas, diversions may also reduce the expenditure of public and private funds for cleaning up and hauling away of sediments.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

Diversions must be designed and installed with adequate capacity to handle runoff of a design frequency for the purpose to be served. Adequate maintenance must be provided to insure proper funtioning. Sediment deposits within the channel should be removed as needed to maintain capacity and reduce channel blockage. Components of a diversion system may include but are not limited to:

- Access Road
- Diversion
- Grade Stabilization Structures
- Grassed Waterway or Outlet
- Hillside Ditch
- Lined Waterway or Outlet

Standards for the above practices are available for review at Resource Conservation District offices serving each county.

Administrative requirements:

This control measure should be included in the developer's plan and should be prepared and approved by responsible public agencies prior to issuing a permit. Local city and county governments would require adequate staffing to administer the review and permit process. In the case of construction by individual landowners, generally the control by local governmental agencies will vary according to the requirements of local ordinances (grading permits, etc.) and whether the construction will affect other properties or public waters.

Legal/political considerations:

Water rights may be a problem and must be resolved where there is a change in the stream pattern such as diversion into an adjacent watershed. Local governments may have control over the surface drainage, grading and the points of discharge of runoff waters. Earthwork and grading must comply with the requirements of local grading ordinances.

Fiscal considerations:

Costs for this control measure are normally the landowners responsibility on agricultural lands with possible cost sharing by the United States Department of Agriculture. Costs for construction sites are normally the responsibility of the developer. Governmental agencies bear the costs where public improvements are involved.

POTENTIAL IMPACTS

Environmental impacts:

The environmental impacts of constructing diversion structures such as dust, air pollution and construction noise would be temporary, only during construction and until vegetative or other protective measures are installed. Dust could be partially controlled by watering down of the construction site. The diversions could improve the visual appearance of the site if carefully landscaped and also could provide valuable wildlife habitat if desired. Runoff water quality would be improved by the reduction or elimination of sediment which would otherwise have been carried by the runoff.

Socioeconomic impacts:

Diversion construction would create short-term employment opportunities during construction with a possibility of additional employment opportunity for maintenance depending on the extent of such installed measures.

EVALUATION

Portion of the overall problem this measure would affect:

Diverting runoff from known areas of sediment accumulation will deal only with the sediment eroded from the particular areas involved.

Potential effectiveness on affected portion:

This control measure could divert virtually all runoff away from the specific area subject to erosion.

Anticipated effectiveness in actual practice:

In actual practice, the diversion structures can be expected to divert virtually all runoff from the specific sediment source area, thereby removing each treated area from the overall problem and reducing downstream sedimentation.

COST CONSIDERATIONS

Costs can vary considerably for the different sites depending on the specific site conditions, terrain, soils, topography and accessibility. Types of construction equipment to be used will also have a significant bearing on the cost.

EXAMPLES

A diversion channel was constructed to collect runoff from a paved utility company area and small adjacent area, and to divert the runoff away from homes downhill from the paved area. Approximately 500 lineal feet of diversion were constructed with a depth of 2 feet. A 25-foot loose rock riprap outlet channel joins the diversion to a stable discharge point. The outlet channel is trapezoidal with a depth of 2 feet, 2:1 side slopes, 2-foot bottom width and 10-foot top width. Approximately 10 cubic yards of rock riprap were required.

The diversion and outlet channel carry approximately 10 cubic feet per second flow. The system was constructed in 1973 and has functioned successfully.

Practice components for this example are Diversion and Lined Waterway or Outlet.

REFERENCES

1. Soil Conservation Service, "National Engineering Handbook, Section 2, Engineering Practice Standards," U.S. Department of Agriculture, Washington, D.C., April 1971

2. Soil Conservation Service, "Field Office Technical Guide," U. S. Department of Agriculture, District Field Offices (unpublished).

	Control Measure	Objective
RCD-7	Grade Stabilization Structures	To stabilize the channel grade and reduce erosion and sedimentation

SUMMARY DESCRIPTION

This control measure consists of constructing a structure to stabilize the grade or to control head cutting in natural or artificial channels. Environmental and pollution hazards will be reduced. The measure may include check dams and ponds formed by earth dams. Structures may be constructed of concrete, rock, masonry, steel, aluminum and treated lumber in addition to earthfill. Simple structures may also be used, such as sand bags, brush and rock, and sodded earth barriers, to name a few types. This control measure would serve to reduce erosive grades to non-erosive grades, thereby reducing the runoff velocity and reducing erosion and sedimentation.

APPLICABILITY

This control measure applies where the concentration and flow velocity of runoff in a channel are such that structures are required to stabilize the grade or to control gully erosion. Special attention should be given to maintaining or improving habitat for fish and wildlife where applicable. This measure is applicable to agricultural land, urban areas, developing areas and construction sites.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure could benefit flood control programs and could reduce flood and sediment damages to public and private properties. Groundwater recharge could be obtained by providing more infiltration opportunity in those areas having high infiltration rates. Water for beneficial use may be available in those sites where a pond is formed by the construction of a structure. By reducing sediment deposition, the cost of cleaning up and hauling away of sediment by governmental and private agencies will be reduced.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

This control measure will require site investigation, soil mechanics study, hydrologic study and complete design, plans and specifications, the extent to be determined by the magnitude of the project. Major structures will require complete analysis; low-head simple structures will require only minor analysis.

Provision must be made for maintenance to insure proper functioning at all times.

Component standards for this control measure may include but are not limited to:

- Access Roads
- Grade Stabilization Structures
- Lined Waterway or Outlet
- Ponds
- Pond Sealing or Lining

Standards and guide specifications for these practices are available for review at Resource Conservation District offices serving each county.

Administrative requirements:

This control measure would have to be designed and constructed under the jurisdiction of administrative and public works staffs of governmental agencies, except for those facilities constructed by individual landowners on their property and which do not affect other properties or public facilities. Staffing of public works agencies would have to be adequate to review plans of developers and to design and supervise facilities constructed with public funds. Technical assistance on non-public facilities is available from Resource Conservation Districts for those landowners within the district. Implementation of this measure could increase the district work load and require administrative analysis and decision as to the need for additional personnel.

Legal/political considerations:

Water rights and land ownership should be considered where pertinent to the project. Compliance with all grading ordinances is required. Other local ordinances may also be applicable. Review of plans and issuance of construction permits by local governmental or state agencies may be required for the larger structures depending on size, cost or degree of hazard.

Fiscal considerations:

Costs for this control measure would be the responsibility of the developer on developing sites. Costs on public rights-of-way would normally be the responsibility of a government agency or by a public assessment district. Costs on other private property would normally be borne by the individual landowner or group of landowners with possible cost-sharing for eligible projects by the United States Department of Agriculture.

POTENTIAL IMPACTS

Environmental impacts:

The environmental impact of constructing grade stabilization structures such as dust, air pollution and construction noise would be temporary. Dust could be controlled by watering around the construction site and on access roads. Runoff water quality would be improved by the elimination or reduction of sediments which would otherwise have been carried downstream by the runoff.

An adverse environmental impact could be the creation of mosquito breeding areas in ponded water, if this should occur, and this would require a mosquito abatement program.

Socioeconomic impacts:

This measure would offer temporary employment opportunity during the construction period. Additional employment may also be available for maintenance of the facilities.

EVALUATION

Portion of the overall problem this measure would affect:

This measure would reduce or eliminate sediment accumulation only from runoff in the particular stream or channel being stabilized.

Potential effectiveness on affected portion:

This control measure could potentially eliminate virtually all pollutants from the stream or channel reach being stabilized. Land treatment measures in the watershed above the controlled reach of the channel would be required to reduce sedimentation from the specific channel reach if sediment from the upper watershed is a problem.

Anticipated effectiveness in actual practice:

In actual practice, the grade stabilization structures can be expected to eliminate virtually all sediments eroded from the stream or channel being stabilized, thereby removing this area from the overall problem.

COST CONSIDERATIONS

Costs for Grade Stabilization Structures can vary over an extremely wide range since there are many different structure types, a wide range of structure sizes and a considerable variation in site conditions. Examples and costs of typical structures are covered under the EXAMPLES section.

EXAMPLES

1. Contra Costa County

This example is one of a number of grade stabilization structures installed on a major stream within the county. The structures were constructed to stabilize the stream channel by controlling degradation of the channel and to reduce erosion and sediments which otherwise would be carried into the downstream reaches of the stream. This structure was constructed in 1961 by formal contract and along with the other similar structures has kept the improved reach of the stream in a stabilized condition with no further significant channel degradation. This channel improvement by grade stabilization structures is particularly significant in view of the change in land use along the channel from agriculture to extensive residential development.

It should be pointed out that sediments from erosion within the upper watershed can still pass through the improved channel reach and be deposited in the lower watershed. Control measures within the upper watershed would be required to reduce or eliminate these sediments.

The structure is a folded weir structure (box inlet weir) with a total weir width of 67.5 feet and depth of 15.5 feet to handle the runoff from approximately 30,000 acres. The total drop in the structure from weir crest to channel invert is 13 feet. Downstream trapezoidal side walls of the structure stilling basin are 36 feet in length and 21 feet high with the immediate downstream reach below the stilling basin protected with grouted rock riprap. The total drop from top of headwall to stilling basin invert is 28.5 feet.

Bid Items and costs exclusive of planning, engineering, supervision and inspection were as follows: (low bidder)

ITEM	QUANTITY-UNIT COST	COST
Clearing and Grubbing	Lump Sum	$ 3,000
Channel Excavation	2112 CY @ $3.00	6,336
Channel Compacted Fill	620 CY @ 1.00	620
Gravel Filter	349 CY @ 14.00	4,886
Rock Riprap	208.7 CY @ 12.00	2,504
Concrete Grout	83.6 CY @ 25.00	2,090
Concrete	319.1 CY @100.00	31,910
Reinforcing Steel	40,041 Lbs.@ .15	6,006
Road Drains	Lump Sum	1,800
	Total Bid Cost:	$59,152

EXAMPLES (continued)

1. Contra Costa County

This is the cost in 1961 for a major grade stabilization structure. The Engineering News Record construction cost index for 1977 is almost triple that for 1961 so the costs for such a structure in 1977 could be well in excess of $100,000.

2. Contra Costa County

A reinforced concrete grade stabilization structure on a reach of Sycamore Creek with a drainage area of 2,300 acres is the subject of this Example. The structure will carry approximately 850 cubic feet per second flow. The weir section is 11 feet wide and 7'9" high. The drop from weir crest to downstream apron is 6 feet. The amount of concrete placed in the structure is 17 cubic yards. The structure was constructed in 1960 and has helped to stabilize portions of the creek along with other similar structures. No information as to construction costs was available.

3. Minor Grade Stabilization Structure (no specific locations)

An example of a minor grade stabilization structure would be a small grouted rock riprap check dam 2 feet high, 5 foot average width with about a 2-foot thick weir crest and using approximately 2 cubic yards of masonry. The structure would involve a small compacted earth fill dam with grouted rock across the weir section and downstream face of the earthfill. Such a structure would serve to stabilize a small gully with a small drainage area. An estimated cost would be about $450, or $225 per cubic yard of masonry. This is a high cost per cubic yard of masonry, however the cost is estimated using only hand labor and unit costs run high on small jobs.

Other Examples would be small gravel and earth check dams, sand bag dams, brush and wire-post check dams and other simple structures. Costs could be as low as $40-$50 for the most simple structure.

REFERENCES

1. Soil Conservation Service, "National Engineering Handbook, Section 2, Engineering Practice Standards," U. S. Department of Agriculture, Washington, D.C., April, 1971.

2. Soil Conservation Service "Office File Records," U.S. Department of Agriculture Soil Conservation Service, Concord, California.

3. U. S. Environmental Protection Agency, "Comparative Costs of Erosion and Sediment Control, Construction Activities," Washington, D.C., EPA 430/9-73-016, July 1973.

	Control Measure	Objective
RCD-8	Pasture and Range Management	Maintain adequate plant cover to protect the soil from erosion while maintaining or improving desirable vegetation for grazing

SUMMARY DESCRIPTION

Pasture and Rangeland Management consists of grazing practices designed to allow for adequate plant residues and suitable plant cover for erosion protection during the rainy season. Management practices also are used to maintain or improve desirable forage species. Livestock should be managed to leave adequate plant residues for erosion control and sustained forage production. Fencing and water and salt distribution are needed in achieving proper distribution of grazing. Livestock grazing can be rotated between fields or may need to be postponed for a year to allow the vegetation to form a better cover. Seeding and fertilization practices are necessary when needed to improve the quality and quantity of plant cover.

APPLICABILITY

This measure is used on pasture and rangeland. It applies where desirable pasture and rangeland plants are depleted and plant cover does not protect the soil. Usually most fields have been overgrazed. Small fields are more apt to be subject to overgrazing because management alternatives are fewer and control measures are more costly in proportion to the area treated.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure would protect the land where conservation practices are applied and would benefit downstream properties. Runoff and sediment would be controlled. The amount of public funds needed for flood control and sediment removal would be reduced.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

The needs for seeding will depend on site conditions including soils, topography, plant species and plant density. Components of Pasture and Range Management may include:

Deferred Grazing	Hillside Ditch
Emergency Seeding of Burned Areas	Pasture and Hayland Management
Fertilizing (pastureland)	Pasture and Hayland Planting
Fertilizing (rangeland)	Pipeline
Fencing	Pond
Firebreak	Proper Grazing Use
	Range Seeding
	Spring Development

Standards and specifications for the above practices are available for review in Resource Conservation District offices serving each county.

Administrative requirements:

This control measure would have to be implemented by the individual landowner. Technical assistance is available from Resource Conservation Districts for those landowners within the district. Implementation of this measure could increase the district workload and require administrative analysis and decisions as to the need for additional personnel.

Legal/political considerations:

A local ordinance for fire districts can be a contributor to sediment sources. Firebreaks may be required along property lines. Vegetation is removed usually by disking. Erosion can be a problem, where the property boundary is on a slope.

Fiscal considerations:

Costs for this control measure are normally the individual landowner's responsibility. There could be cost sharing by the United States Department of Agriculture on some of the component practices needed to implement this measure.

POTENTIAL IMPACTS

Environmental impacts:

This measure would reduce surface runoff and enhance the appearance of the land that has been overgrazed. It could increase the fire hazard especially on fields where grazing is deferred for a year.

Socioeconomic impacts:

Range and pasture improvement practices result in more and better quality forage to support a livestock enterprise, thereby reducing costs to producer and consumer.

EVALUATION

Portion of the overall problem this measure would affect:

The total extent of land subject to overgrazing can vary considerably from season to season. The weather and changing economic conditions can have an adverse impact on efforts to maintain a good plant cover for erosion protection.

Potential effectiveness on affected portion:

Soil erosion would be reduced and maintained within soil-loss tolerance rates.

Anticipated effectiveness in actual practice:

Circumstances may be such that some areas cannot be totally treated by practical methods. The losses may be above the soil-loss tolerance rates.

COST CONSIDERATIONS

Some of the major costs can be for water development and interior cross fencing [illegible] these facilities are presently inadequate. The investment for fertilizers [illegible] can be high considering the uncertainties of weather but long term [illegible] these investments are profitable.

EXAMPLES

Fertilizing Rangeland

Fertilizing is a practice to stimulate the growth of grasses to increase the amount of cover for soil protection and provide more and better quality forage for livestock grazing. Trials were conducted at Sunol in Alameda County on rangeland using combinations of Nitrogen and Phosphorus fertilizers. The results showed that fertilize would improve cover for soil and moisture conservation, increase the quality of forage, and facilitate grazing management. Several ranchers in Alameda County broadcast fertilizer on their native pastures in October. Their results showed that there were four to seven times as much feed available at the end of February from the fertilized fields as compared to untreated areas. This meant more cover was produced for soil protection during the early part of the year and a better quality feed produced during the cool season.

The results of fifteen years of tests fertilizing California annual rangeland have been summarized by the California Agricultural Experiment Station. Fertilizers were broadcast by rig or aerial application in October or November. Nitrogenous fertilizers with adequate Phosphorous and Sulphur or those present in the soil, stimulated early and continued winter and spring growth of grasses. An economic evaluation showed that the weight gain of cattle increased from 60 to 170 pounds per acre. The average grazing income increased from $9.95 to $15.05 per acre by fertilization in the first year.

Fertilization where needed could be economically feasible and would provide much more vegetative cover for soil protection.

REFERENCES

1. Bently and Talbot, "Efficient Use of Annual Plants on Cattle Ranges in California Foothills," U.S. Department of Agriculture Circular 870, 1951.

2. Soil Conservation Service, "Field Office Technical Guide," U.S. Department of Agriculture, District Field Office (unpublished).

3. Berry, L. J. and Martin, W. E., "Effects of Nitrogenous Fertilizers on California Range," California Agricultural Experiment Station, Bulletin 846, September 1970.

4. Soil Conservation Service, "National Range Handbook - 1, July 13, 1976," U.S. Department of Agriculture, Davis, California.

5. Berry, L. J. and Martin, W. E., et. al., "Third Progress Report, Results of 16 Grazing Tests on Annual Range, 1955-56 Season," University of California, Cooperative Extension Service.

6. Berry, L.J., Martin, W.E. and Williams, W.A., "Fourth Progress Report, Results of 13 Grazing Tests on Annual Range, 1956-57 Season," University of California, Cooperative Extension Service.

7. Hogland, O. K., Miller, H. W. and Hafenrichter, "Application of Fertilizers to Aid Conservation on Annual Forage Range," Journal of Range Management, Vol. 5, No. 2, March 1952.

8. Slayback, Robert D., "Thirty Acres That Revolutionized Grazing," Western Livestock Journal, January 1965.

	Control Measure	Objective
RCD-9	Runoff and Sediment Control Ponds and Basins	To reduce peak flow and volume of runoff and to collect and store sediment and other debris

SUMMARY DESCRIPTION

This control measure consists of constructing ponds or basins for the storage and control of runoff, diversion of runoff, and the collection and storage of debris. The impoundments are formed by constructing a dam across a waterway or stream, or by construction at other suitable locations for off-channel storage. Runoff control ponds store runoff waters for release at a reduced rate of flow, thereby reducing the peak flow and reducing the erosion caused by high flows. Diversion dams may be either ponds or check dams which divert part or all of the runoff from an unstable, erodible waterway or stream to a stable, non-eroding water course. Debris basins are ponds which reduce or abate pollution by providing a basin to trap and store sediment, agricultural waste and other pollutants, and to trap sediments originating from construction.

APPLICABILITY

Sites for ponds must be suitable for construction for the purpose to be served. Adequate capacity must be available. Topography, geology and soils must be suitable for construction of a safe dam. Site conditions shall be such that the runoff for the design storm can be safely passed through a natural or constructed spillway. Debris basins may be used where physical conditions or land ownership preclude the treatment of the sediment source by installation of erosion control measures to keep soil or other material in place; or where a debris basin offers the most practical solution to the problem.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

Many ponds have multiple purpose uses. On sites where permanent storage is available, ponds may have public uses such as recreation, irrigation, fish and wildlife, fire control and other related benefits in addition to their pollution control function. Flood control benefits could be obtained and this would reduce flood damage to public and private properties. Ground water recharge may be possible in those areas having high infiltration rates.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

This control measure will require thorough site investigation, soil mechanics studies, hydrologic studies and complete design, plans and specifications, the extent to be determined depending on the magnitude of the project. Provision must be made for a maintenance program to insure proper functioning at all times. Since failure of any impoundment could cause extensive damage and possible loss of life, every precaution must be taken in investigation, design and construction to insure a safe structure. Component standards for this control measure may include but are not limited to:

- Access Road
- Dam, Diversion
- Debris Basin
- Diversion
- Lined Waterway or Outlet
- Pipeline
- Pond
- Pond Sealing or Lining

Standards and specification guides for these practices are available for review at Resource Conservation District offices serving each county.

Administrative requirements:

This control measure would have to be designed and constructed under jurisdiction of administrative and public works staffs of local governments except for those facilities constructed by individual landowners on their property and not affecting any other public facilities. Increased public works staffing may be required. Technical assistance is available from Resource Conservation Districts to landowners within the District. Implementation of this measure could increase the district work load and require administrative analysis and decision as to the need for additional personnel.

Legal/political considerations:

Dams exceeding a specific capacity and size require review and approval of designs and plans and specifications by the California Department of Water Resources, Supervision of Safety for Dams Section. Water rights must be considered when they pertain to a specific project. Land ownership boundaries must be considered where the project extends over more than one property. Local ordinances pertaining to grading and excavation should be given consideration. Other local ordinances may be applicable.

Fiscal considerations:

Costs for this control measure would be the responsibility of the developer, a governmental agency or a special assessment district. Costs on private property would be borne by the individual landowner or group of landowners with possible cost-sharing for those eligible projects by the United States Department of Agriculture.

POTENTIAL IMPACTS

Environmental impacts:

Dust and air pollution and noise will be a problem during construction. Dust may be controlled by watering during construction. Good landscaping can improve the appearance after construction and make the site visually pleasing.

An adverse environmental impact could be the creation of mosquito breeding areas in standing water, if this should occur, and this would require a mosquito abatement program.

Socioeconomic impacts:

This measure would offer temporary construction employment opportunity during the construction period. Additional employment opportunity also may be available for maintenance of facilities.

EVALUATION

Portion of the overall problem this measure would affect:

Collecting sediment from known sediment source areas will deal only with the pollution accumulation from that area.

Potential effectiveness on affected portion:

This control measure could potentially collect all pollutants from known source areas.

Anticipated effectiveness in actual practice:

This control measure can be expected to collect practically all sediments from the source areas, thereby eliminating such controlled area from the overall problem.

COST CONSIDERATIONS

Construction costs for this control measure vary widely depending on site conditions, type of soil materials, foundation problems, climate, access and equipment requirements for the specific job. Each pond or basin must be planned and costs determined based on the individual site conditions. The type of contract is also an important factor, whether by formal contract with a large contractor or force account with a small contractor. The formal contract will have numerous costs not ordinarily a factor with smaller contractors.

EXAMPLES

1. Alameda County

Ponds in many cases have multiple purpose uses such as flood control, sediment and debris collection, and storage of irrigation water and stock water.

Ponds often provide indirect erosion control benefits in addition to their primary purpose. Stock water ponds provide erosion and sediment control benefits by improved distribution of cattle grazing on range and pasture lands through better distribution of watering facilities. Stock water is distributed to watering troughs at various locations by pipelines. The result is less concentration of stock grazing in certain areas, or overgrazing, and better maintenance of vegetative cover. The improved vegetative cover will provide greater protection against erosion. Ponds will also collect sediments regardless of the primary purpose of the pond.

An example of a pond is one with three acre-feet (975,000 gallons) capacity containing 4,000 cubic yards of earthfill. Water was provided for 50 cows and 200 sheep grazing on 300 acres. The cost of the pond in 1960 was $1,[illegible] or 25 cents per cubic yard of earthfill in place. The pond was built by a small contractor with minimum overhead. Costs do not include the pipe through the fill or distribution facilities. At current prices, it is estimated that the costs would be more than doubled.

Normally, the lower 2 - 5 foot depth of a pond below the outlet pipe is reserved for collection of sediment. Sediments must be removed periodically in order to maintain adequate capacity for collecting sediment.

Practice components for this example are Access Road, Pipeline and Pond.

2. Contra Costa County

A debris basin consists of an earthfill dam with a 14 foot top width, 3:1 upstream slope and 2:1 downstream slope, Depth of basin available for sediment collection below the top of the riser pipe is approximately [illegible] feet. [illegible] 30 inch corrugated metal conduit with a 4[illegible] inch riser and attached [illegible]

EXAMPLES, continued

permits trash-free flow through the dam. The basin collects sediment from the drainage area of 107 acres. Information as to the sediment storage volume was not available.

Periodic maintenance is required to remove accumulated sediment from the basin as the sediment storage becomes filled.

This debris basin is one of five such basins in the watersheds upstream of a large water storage reservoir, and helps to eliminate some sediment which otherwise would be deposited in the reservoir.

Practice components for this example are Access Road, Debris Basin and Pond.

REFERENCES

1. Soil Conservation Service, "National Engineering Handbook, Section 2, Engineering Practice Standards", U.S. Department of Agriculture, Washington, D.C., April 1971.
2. Soil Conservation Service, "Field Office Technical Guide", U.S. Department of Agriculture, District Field Offices. (unpublished)

RCD-10	Control Measure Streambank and Channel Protection and Stabilization	Objective Reduce the amount of sediment and other pollution

SUMMARY DESCRIPTION

This control measure consists of stabilizing and protecting banks of streams or excavated channels against scour and erosion with vegetative or structural measures and stabilizing stream channels by construction of suitable control structures. The purposes are (1) to prevent the loss of land or damage to cropland, utilities, roads, buildings or other facilities adjacent to the channel; (2) to maintain the capacity of the channel; (3) to control channel meander which would cause erosion and sedimentation which would adversely affect downstream facilities; (4) to reduce or eliminate sediment loads causing downstream damages and pollution or to improve the stream for recreational use or as fish and wildlife habitat; and (5) to control aggradation or degradation in a stream channel where downstream sediment damage occurs.

Numerous methods of control may be used depending on the velocity and volume of flow, peak flow, soil and geologic conditions, water table elevation and the quantity and characteristics of sediments. The highest level of control includes channel linings of concrete or rock riprap, either grouted or ungrouted. Protective revetments along the lower edge of a bank may consist of timber, fencing with or without brush backing, sacked concrete, gabions, piling, or other commercial manufactured steel or concrete pre-fabricated structures back filled with rock, gravel or earth. Jetties or deflectors which project from the streambank into the stream are used to protect banks at curves and stream reaches subjected to erosion by high velocity currents. Jetties may consist of posts, piling, fencing, rock, brush, sacked concrete or other materials which provide a firm barrier against stream velocities. In some situations bank sloping alone may provide adequate control by reducing the slope of stream banks to provide a suitable condition for the establishment of vegetative protection. In streams or channels obstructed by fallen trees, brush, sand and gravel bars or other debris, control may be obtained by merely clearing and snagging to obtain an unobstructed channel.

Structural measures such as check dams may be required to control the grade and velocity of flow where damaging aggradation and degradation occurs in a stream channel. Such structures may be concrete, grouted or ungrouted rock, timber, sacked concrete, gabions, ponds, or such simple structures as brush or post and wire dams, depending on the site and severity of the problem. It should be recognized that channels may aggrade or degrade during a given storm or over short periods of time. A channel should be considered stable if the channel bottom remains essentially at the same elevation over a long period of time and with little or no sedimentation downstream of the specific channel reach being improved.

Improved land use practices in upstream watersheds will also have a beneficial effect in reducing runoff, thereby reducing erosion and resulting sedimentation in downstream channels.

APPLICABILITY

This practice applies to natural or excavated channels where the streambanks are subject to erosion from the action of water or debris or to damage from livestock or vehicular traffic, or where stream channels are undergoing damaging aggradation or degradation, with damaging sedimentation to downstream areas.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure could benefit flood control programs and could reduce damage to public and private properties. By reducing sediment deposition, the cost of cleaning up and hauling away of sediment by both governmental and private agencies will be considerably reduced. Aesthetics may be improved and be more pleasing to the public eye with streambank and channel improvements.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

This control measure will require hydrologic analysis, site investigation, soil mechanics study, and complete design, plans and specifications, the extent to be determined by the magnitude of the project. Major works of improvement will require complete analysis; simple problems will require only minor analysis. Provision must be made for adequate maintenance to insure proper functioning at all times.

Design analysis must be sufficiently detailed to insure that any proposed controls will not aggravate the situation and cause further problems downstream of the site to be controlled.

Component standards for this control measure may include but are not limited to:

- Access Roads
- Clearing and Snagging
- Critical Area Planting
- Debris Basin
- Dike
- Grade Stabilization Structure
- Open Channel
- Pond
- Pond Sealing or Lining
- Streambank Protection
- Stream Channel Stabilization
- Tree Planting

Standards and specification guides for these practices are available for review at Resource Conservation District offices serving each county.

Administrative requirements:

This control measure would have to be designed and constructed under the jurisdiction of public works staffs on public projects. Facilities to be constructed by individual land owners or developers on their properties could be subject to review and approval of governmental agencies in many locations. Staffing of public works agencies would have to be adequate to handle these responsibilities.

Technical assistance on private facilities is available from Resource Conservation Districts for those land owners within the district. Implementation of this measure could increase the district workload and require administrative analysis and decision as to the need for additional personnel.

Legal/political considerations:

Water rights and land ownership should be considered where pertinent to a specific project. Local land use, drainage and grading ordinances may be applicable to this control measure. California Department of Fish and Game regulations could apply to perennial streams involving wildlife and fishing.

Fiscal considerations:

Costs for this control measure on public projects would be the responsibility of government agencies or public assessment districts. The developer would pay costs for this measure on developing sites unless financial assistance is available from public funds for a general public benefit. Costs on other private property would normally be borne by the land owner or group of land owners with possible cost-sharing for eligible projects by the U. S. Department of Agriculture.

POTENTIAL IMPACTS

Environmental impacts:

The environmental impact of this control measure such as dust, air pollution and construction noise would be temporary. Dust could be controlled by watering around the construction site and on access roads. Runoff water quality would be improved by the reduction or elimination of sediments which would otherwise have been carried downstream by the runoff. The improved appearance of many sites after construction would be pleasing to the eye and a definite public benefit in that respect.

Socioeconomic impacts:

This measure would offer temporary employment opportunity during the construction period. Additional employment may also be available for maintenance of the facilities.

Losses to business in commercial areas would be reduced by the reduction or elimination of sediments in such areas which could make it difficult for customers to patronize such businesses when sediments were present. Excessive sedimentation could also affect other business or industrial areas making travel to such locations difficult or impossible.

EVALUATION

Portion of the overall problem this measure would affect:

This control measure will protect the streambank or stabilize the channel grade for only the channel reach that is treated, thereby controlling runoff and reducing erosion and resulting sedimentation downstream.

Potential effectiveness on affected portion:

This control measure could potentially eliminate virtually all pollutants from the specific stream or channel reach being controlled; however, land treatment measures in the upper watershed above the controlled site would be required to reduce or eliminate completely sedimentation from the specific stream or channel if sediment from the upper watershed is a problem.

Anticipated effectiveness in actual practice:

In actual practice, this measure can be expected to eliminate virtually all sediments eroded from the stream or channel reach being stabilized or protected, thereby removing this specific area from the sedimentation problem.

COST CONSIDERATIONS

Costs for this Control Measure would vary considerably depending on such factors as the type and extent of control, materials required, hydrology, access to the site and site conditions such as topography, geology and soils. There are many different methods of streambank and channel erosion controls. Detailed investigation and design are normally required for each individual site except for the most simple problems.

Costs for a typical streambank protection project are included in the EXAMPLES section

EXAMPLES

Contra Costa County

A streambank and channel project along 960 lineal feet of stream channel, involved excavation and compacted earth fill to shape the channel where irregular channel banks originally existed. The channel grade had been stabilized previously by construction of a grade stabilization structure immediately downstream of this channel reach. Rock riprap streambank protection was also placed along a sharp curve for a distance of 180 lineal feet where a side drainage entered the main stream channel. The purpose of the rock riprap was to protect the bank from the flow of the main stream and to protect existing homes along the streambank. This project was constructed in 1959 and has functioned satisfactorily.

EXAMPLES (continued)

Contra Costa County

This project was constructed by formal contract at the following costs (low bidder)

	ITEM	QUANTITY	UNIT COST	COST
1.	Clearing and Grubbing		Lump Sum	$ 3,750
2.	Channel Excavation	5,470 C.Y.	$ 1.00	5,470
3.	Channel Compacted Fill	4,970 C.Y.	.74	3,678
4.	Rock Riprap Revetment	416 C.Y.	12.00	4,992
			Total Cost:	$17,890

With the present increase in cost, it is estimated that this same project would cost about $50,000 or more at current prices.

Practice components of this project are Access Road, Clearing and Snagging, Open Channel and Streambank Protection.

REFERENCES:

1. Soil Conservation Service, "National Engineering Handbook, Section 2, Engineering Practice Standards," U.S. Department of Agriculture, Washington, D. C., April 1971.

	Control Measure	Objective
RCD-11	Waste Management System	To manage liquid and solid waste to reduce pollution

SUMMARY DESCRIPTION

This control measure consists of a planned system to manage liquid and solid animal and agricultural waste, including surface runoff from concentrated waste areas such as animal feed lots, with ultimate disposal in a manner which does not degrade air, soil or water resources, and which protects public health and safety. The systems are planned to preclude discharge of animal and agricultural pollutants to surface or ground water and, to the fullest practicable extent, to recycle waste through soil and plants. The term waste as used in this control measure includes both liquid and solid waste, waste water from cleaning dairy barns or food processing, and polluted runoff such as that from animal feed lots. This measure includes diversions or collection facilities to collect polluted runoff, temporary storage ponds or structures, lagoons for biological treatment of wastes, and disposal facilities by irrigation or hauling and spreading on the land.

APPLICABILITY

This control measure applies where: (1) waste generated by agricultural production or processing needs treatment and safe disposal; (2) dairy wash water and feed lot runoff contribute pollutants to receiving water: (3) temporary storage facilities and treatment lagoons can be constructed as needed for waste management without being a nuisance to residential and public areas: and (4) soil, water and plant resources are adequate for proper management and disposal of the waste.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure would improve the quality of receiving waters by eliminating or reducing the amount of waste from agricultural and processing activities. Waters would be more suitable for recreation and for fish and wildlife, thereby benefiting public use. It would also benefit public health, water supply and odor abatement, all of major concern to public agencies and the general public.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

This control measure will require site investigation, soils and geology study, and complete design, plans and specifications; the extent to be determined by the magnitude of such a project. Provision must be made for operation and maintenance as necessary to insure proper functioning at all times. Requirements of Regional Water Quality Control Boards must be met to obtain adequate final condition of waste for ultimate disposal.

Component standards for this control measure may include but are not limited to:

- Conservation Irrigation System
- Debris Basin
- Dike
- Diversion
- Drainage System Structure
- Fencing
- Land Smoothing
- Lined Waterway or Outlet
- Pond
- Pond Sealing or Lining
- Subsurface Drain
- Waste Management System
- Waste Storage Pond
- Waste Storage Structure
- Waste Treatment Lagoon

Standards and specification guides for the above practices are available for review at Resource Conservation District offices serving each county.

Administrative requirements:

This control measure would have to be implemented by individual landowners, feed lot operators and processing plants. Management of waste must meet the requirements of Regional Water Quality Control Board and local ordinances which would require adequate staffing of these agencies for review and inspection. Technical assistance is available from Resource Conservation Districts for those landowners within the district. Implementation of this measure by landowners could increase the district workload and require administrative analysis and decision as to the need for additional district personnel.

Legal/political considerations:

This control measure is subject to Regional Water Quality Control Board regulations. It is required that animal confinement and treatment facilities plus adjacent croplands have the capacity to retain surface drainage from manure storage areas and feed lots, plus any washwater during a 10-year 24-hour storm. No discharge is permitted into streams or other receiving waters for this storm event or lesser events. Animal confinement facilities, including storage and treatment facilities and feed lots, shall be protected from runoff from adjacent areas during 20-year peak stream flows for existing facilities and 100-year peak stream flows for new facilities.

Local excavation and grading ordinances are applicable to all construction for this measure. Other local ordinances may also apply.

Disposal of liquids and solids after treatment should be done in a manner not causing a public health hazard

Fiscal considerations:

Costs for this control measure would be the responsibility of the individual landowner, feed lot operator or processing plant. Costs of the individual landowner for facilities such as diversions, storage units and treatment lagoons may qualify for cost-sharing assistance from the United States Department of Agriculture.

POTENTIAL IMPACTS

Environmental impacts:

The environmental impact of constructing waste management systems such as dust, air pollution and construction noise would be temporary only during construction. Dust could be essentially controlled during this period by watering. Water quality would be improved after the facility begins operation by the elimination or reduction of pollutants which previously would have been carried into receiving waters.

Socioeconomic impacts:

This measure would offer temporary employment opportunity during the construction period with possible additional employment opportunity for operation and maintenance of the facilities.

Improvement of the quality of receiving waters may make them suitable for recreation (fishing, swimming) as a profit making venture depending on whether or not there are other pollution sources contributing to these same waters.

EVALUATION

Portion of the overall problem this measure would affect:

This control measure would eliminate or reduce pollution only from the feed lot, dairy or other facility or adjacent areas contributing to the problem.

Potential effectiveness on affected portion:

This control measure could potentially manage and retain all pollution from the specified area under control.

Anticipated effectiveness in actual practice:

In actual practice, and with proper maintenance, this control measure can be expected to eliminate virtually all pollution from the area under control, thus eliminating such source areas from the problem. In the event of infrequent storm events greater than the design frequency of the system, some polluted runoff is possible due to runoff exceeding the capacity of the system.

COST CONSIDERATIONS

Construction costs for wastewater management systems vary widely depending on many factors such as site conditions, cattle herd size, climate, soils and the system components required to meet wastewater control requirements. Each system must be planned and costs determined based on the individual site conditions.

A publication of the California Regional Water Quality Control Board, Central Valley Region, provides construction costs for 128 projects installed during the period 1970-1976. Costs were adjusted to a 1975 cost basis and it is estimated such costs could be approximately 30-40 percent higher in 1977. Following is a tabulation of costs from the publication (1975 costs):

WASTE MANAGEMENT SYSTEM COSTS

SOURCE	NO. OF PROJECTS	NO. OF COWS	COST RANGE PER PROJECT
Personal Contact	31 (without flushdown)	50-1,100	\$1,500-\$22,500
Personal Contact	22 (with flushdown)	300-800	\$8,300-\$56,300
Soil Conservation Service	75 (without flushdown)	50-1,200	\$2,410-\$26,240

Source: Peck, Omer; "Costs and Benefits of Dairy Wastewater Handling", California Regional Water Quality Control Board, Central Valley Region, 1976.

All projects included a wastewater pond or lagoon. Costs also included concrete work, pump, pipe and fencing where such items were required. Information was not provided to indicate those projects requiring such appurtenant construction items.

Flushdown animal waste units are included in 22 of the projects tabulated which obviously increases the construction cost of those projects. In such systems, animal wastes are deposited in confined concrete areas next to milking areas. The concrete surfaces are curbed and sloped so that wastes can be washed away or pumped into wastewater ponds, lagoons or storage structures. Remaining solids in other areas must still be scraped and hauled away. Liquids from the wastewater units can be applied to irrigated lands by sprinkling or surface irrigation methods.

Some facilities will also have mechanical solids separators which separate the solids from the liquids. Costs for such separators reportedly vary from \$2,500 to \$15,000 or more. Such costs are not included in the preceding tabulation of costs.

Following are some typical component unit costs as used in one county for design purposes where a number of waste management systems have already been constructed.

1. Holding ponds, sheepsfoot roller compaction — $1,000-$1,500
2. Roof runoff diversion by gutters and drains — $1,000-$1,500
3. Separator system (1975 costs)
   a. Sieve type — $7,000
   b. Holding tank, 30,000 gallon reinforced concrete block — $8,000
   c. Low head pump with agitator — $3,000
   d. Concrete pad for sieve and solids storage — $2,000
4. Animal waste holding tank — $5,000
   Reinforced concrete block 20 foot diameter x 9 foot depth
   16,500 gallon capacity @ 7 foot depth
5. Waste disposal pipelines (1977 costs)
   a. 4-inch diameter aluminum 20 foot sections — $1.60/lin. ft.
   b. 4-inch diameter PVC plastic, buried — $3.50/lin. ft.
6. Loafing barns, steel (1975 costs)
   a. Loafing facility only — $200/cow
   b. Loafing and feeding — $325/cow
   c. Loafing, feeding and feed storage (hay) — $450/cow

Source: Soil Conservation Service, Marin County.

The preceding unit costs provide guidance only. Each system must be designed to meed herd size and other requirements. Where costs are noted to be 1975 costs, present 1977 costs may be approximately 30-40 percent greater.

Costs for a waste management system in Marin County are included in the Examples section.

EXAMPLES

Marin County

This project consists of four ponds and a portable irrigation system. Animal waste is flushed from the dairy barn into the solid animal waste holding ponds. Three ponds are used which allows rotation use and cleaning of solids from each pond while others are in use. Liquid waste overflows from solids ponds into the liquid holding pond. A portable irrigation system using a 15-horsepower pump and portable aluminim pipe permits sprinkling of the liquid waste onto adjacent irrigable lands. Solids must be removed from the solid waste ponds and spread on fields where it can be utilized in the soil.

Following are construction items and their costs for this project:

1. One liquid and 3 solid animal waste holding ponds — $9,959
2. Portable irrigation system as follows: — $4,500
   a. 15-horsepower irrigation pump
   b. 900 lin. ft. portable aluminum pipe and sprinklers
   c. Installation and wiring (3-phase) for pump
3. Rock and compacted fill material for free stall barn pad plus surfacing for pond clean-out ramps. — $3,900
4. Permits and landscaping — $246

Total — $18,605

EXAMPLES, continued

In addition, a free stall loafing barn with gutters was constructed at a cost of $33,708. However, this was not considered as an animal waste system cost. Also, a portion of the cost of item 3 on the preceding page is for rock and compacted fill for the loafing barn which cost was not separately stated.

REFERENCES

1. Soil Conservation Service "National Engineering Handbook, Section 2, Engineering Practice Standards", U. S. Department of Agriculture, Washington, D.C., April 197

2. Soil Conservation Service, "Agricultural Waste Management Field Manual", U. S. Department of Agriculture, Washington, D.C., August 1975.

3. Peck, Omer, "Costs and Benefits of Dairy Wastewater Handling", California Regional Water Quality Control Board, Central Valley Region, 1976.

RCD-12	Control Measure Watershed, Wildlife and Recreation Land Improvement	Objective Protect potentially erodible areas and improve or maintain opportunities for wildlife and recreation

SUMMARY DESCRIPTION

This measure consists of methods to improve the protection of watershed lands to prevent erosion and sedimentation and enhance opportunities for wildlife and recreation use. Fire protection is essential. Burned over areas are seeded to establish emergency cover. Erosive sites are vegetated with selected plant materials to stabilize the soil. Special plantings are made to improve wildlife habitat and increase the attractivness of planned recreation sites. Access roads and trails are designed and constructed with measures to control erosion. Special protection is given to recreation areas receiving heavy use. Water facilities are developed for fire protection and wildlife needs.

APPLICABILITY

This measure applies to all lands where the primary benefits are watershed protection and wildlife and recreation uses. These lands are either not well suited to crops, grazing or silviculture. The planned use is solely for watershed, wildlife and recreation.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

This control measure would reduce the amounts of sediments that would cause problems on downstream properties. The amount of public funds needed for sediment removal and correction of other related problems would be reduced. In addition to improved water quality, the benefits for recreation and wildlife opportunities should be a consideration in the decision to implement this measure.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

Each site has to be considered in accordance with the soils, topography, climate and other factors along with the planned use. Practices are then selected to be applied which are suited to the intended use and potential of the site.

Component practices of this measure may include but not be limited to:

- Access Road
- Critical Area Planting
- Emergency Seeding of Burned Areas
- Firebreak
- Fish Stream Improvement
- Heavy Use Area Protection
- Pipeline
- Recreation Area Improvement
- Recreation Land Grading and Shaping
- Recreation Trail and Walkway
- Tree Planting
- Wildlife Upland Habitat Management
- Wildlife Watering Facility

Administrative requirements:

This control measure would be implemented by landowners both public and private. The workload for public agencies (such as parks) that are presently staffed, would be increased slightly in applying this measure to lands within their jurisdiction. Technical assistance is available through Resource Conservation Districts to landowners within the district. Implementation could increase the district workload and require administrative analysis and decisions as to the need for additional personnel. Temporary adjustments in personnel may be needed for emergency reasons, such as fires.

Legal/political considerations:

Local ordinances related to grading, excavation or firebreaks should be observed. California Department of Fish and Game regulations could apply to a situation related to wildlife and fisheries.

Consideration needs to be given to urban fringe areas where land is not being managed for any agricultural enterprise because of taxes or other reasons and the land is being held for future development. These areas are often used for recreation purposes even though the user may be trespassing. Ordinances need to be developed toward encouragement of land treatment where needed. These lands now contribute sediment while waiting for the bulldozer.

Fiscal considerations:

Costs of this measure would normally be the responsibility of the individual landowner. Sone of the land is in public ownership and the funds for implementation would come from public sources. In many cases the individual private land owner would need cost-sharing to implement this measure. The benefits to the individual on the kinds of land involved are usually not enough to justify the land treatment.

POTENTIAL IMPACTS

Environmental impacts:

Watershed protection reduces sediment in streams and helps reduce the hazard of flooding and landslides. This measure would improve the habitat for wildlife, increasing the numbers and kinds of species. Scenic values would also be improved, particularly where erosion control plantings are effective for landscaping. The amount of available recreation land could be increased by construction of access trails and selective pruning and thinning of trees and plants.

Socioeconomic impacts:

This measure would provide temporary employment during implementation to do light construction work, install vegetative plantings and make other improvements. A lesser amount of labor would be required for maintenance crews. Policing might be needed for new recreation sites.

EVALUATION

Portion of the overall problem this measure would affect:

The protection of highly erodible watersheds is essential in the overall solution to sediment controls. The total extent of watershed, wildlife and recreation land requiring this measure has not been estimated.

Potential effectiveness on affected portion:

Each treated area could have sediment losses reduced to negligible amounts.

Anticipated effectiveness in actual practice:

It would be impractical to implement this measure on some areas in need of treatment because of the inaccessible nature of the site and lack of suitable soil or other unfavorable conditions.

These lands are susceptible to fires. The loss of vegetative cover on portions of a watershed would impair the effectiveness of the control measure.

COST CONSIDERATIONS

The costs for this measure will vary with the site and level of improvement being planned. Greater expenditures may be required and could be justified around urban fringe areas because of heavy area use, recreational needs and high land values. The additional input may be justified for other benefits than erosion control and sedimentation. As an example, firebreaks may be 20 to 30 feet wide. Near urban areas, a fuel break as wide as 300 feet may be desirable. Hand clearing is very costly but may be necessary for selective removal of vegetation. This would produce desired aesthetic effects and disturb the soil as little as possible.

EXAMPLES

Thousands of acres of Bay Area watershed land could be threatened by fire. In the event of a serious conflagration, the burned watershed poses a threat to downstream lands exposing them to possible flooding and siltation.

A project for fire prevention was initiated for a watershed in Santa Clara County in 1971 and is scheduled for completion in 1980. When this project is completed, it will consist of a network of fuelbreaks, 22 miles of fire roads, 10 helispots and water sotrage tanks. The work is considered about 80 percent complete.

REFERENCES

1. The Resources Agency of California, "Game Management Leaflet No. 3, Making Farms Attractive for Pheasants," Department of Fish and Game, 1416 Ninth St., Sacramento California 95814.

2. The Resources Agency of California, "Game Management Leaflet No. 5, Water Developments for Upland Game Birds," Department of Fish and Game, 1416 Ninth St., Sacramento, California 95814.

3. The Resources Agency of California, "Game Management Leaflet No. 8, Improving Lan Land for California Valley Quail," Department of Fish and Game, 1416 Ninth St., Sacramento, California 95814

4. The Resources Agency of California, "A Plan for California Deer," Department of Fish and Game, 1416 Ninth St., Sacramento, California 95814, March 1976.

5. Cooperative Extension, "California Waterfowl and Its Management," 75-LE-2247, Division of Agricultural Sciences, University of California.

6. Cooperative Extension, "California Birds and How to Improve Their Habitat," Leaflet 2707, Division of Agricultural Sciences, University of California, June

7. Cooperative Extension, "California Upland Game and Its Management," Leaflet 2720, Division of Agricultural Sciences, University of California, July 1975.

8. Cooperative Extension, "California Furbearers and Their Management," Leaflet 2721, Division of Agricultural Sciences, University of California, July 1975.

9. Soil Conservation Service, "More Wildlife Through Soil and Water Conservation," Agriculture Information Bulletin No. 175, U. S. Department of Agriculture.

10. Anderson, Wallace L., "Making Land Produce Useful Wildlife," Farmers' Bulletin No. 2035, U. S. Department of Agriculture.

11. USDA, Forest Service, "Mechanical Methods of Chaparral Modification," Agriculture Handbook No. 487, April 1976.

	Control Measure	Objective
RCD-13	Woodland Protection	Maintain adequate cover for erosion control while maintaining or improving woody vegetation

SUMMARY DESCRIPTION

This control measure consists of managing woodland areas to protect them from erosion and maintain or improve production from the site. Management is applied to maintain an adequate cover to protect the soil. Other special practices are utilized for erosion control. Fire protection is essential. Planting, seeding or other methods of establishing cover may be required.

Special logging and erosion control practices are used to protect the vegetation and soil during and after harvest operations. Roads and other facilities are constructed to control erosion. Protection is given to streams and lakes in all timber operations.

APPLICABILITY

This measure applies on all lands where woody vegetation is now growing, or the planned use is woodland.

RELATIONSHIP TO OTHER PUBLIC ACTIONS

The protection of woodland is important in the overall water quality benefiting a community. Sediment and runoff are controlled while giving consideration to the public need for wood products, recreation opportunities and fish and wildlife considerations.

IMPLEMENTATION REQUIREMENTS

Technical aspects:

The application of this control measure is dependent on soil, topography, erosion potential, timber stand conditions and other considerations.

Component standards of this measure may include but not be limited to:

Access Roads	Livestock Exclusion
Critical Area Planting	Proper Grazing Use
Emergency Seeding of Burned Areas	Tree Planting
Fencing	Woodland Improved Harvesting
Firebreak	Woodland Improvement
Hillside Ditch	Woodland Site Preparation

Standards and Specifications for the above practices are available for review in Resource Conservation District offices serving each county.

Administrative Requirements:

This control measure would have to be implemented by the individual landowner or operator. It could increase the workload on forestry staff in several Bay Area counties having extensive areas of timberland.

Legal/political considerations:

State and local ordinances and regulations must be followed, such as compliance with the State Forest Practice Act 1/ (County Practice Act where applicable) and Fish and Game, and Regional Water Quality Control Board Regulations.

Standards for responsible forest resource management are established by Forest Practice Rules and are enforced by the State Forester.

Fiscal Considerations:

Costs for this measure are normally the individual landowner's responsibility.

POTENTIAL IMPACTS

Environmental impacts:

Full implementation of this measure would reduce sedimentation, while the site produces needed wood products. Multiple use benefits can be achieved as watershed protection is accomplished, giving consideration to fisheries, wildlife, range forage and recreation opportunities.

Socioeconomic impacts:

This measure would help encourage the production of wood products for future generations and improve or maintain the quality and quantity of timber produced.

EVALUATION

Portion of the overall problem this measure would affect:

It was estimated (1969 figures) that about 45% of the commercial forest land, (330,000 acres-approximate) in these counties needed establishment or reinforcement of stand or timber stand improvement. 2/

Forest practice rules must be followed on all lands when harvesting or removing timber. This will require the application of best management practices through a timber harvesting plan.

Potential effectiveness on affected portion:

If fully implemented this measure would control nearly all the sediment for each treated site and keep soil losses within acceptable limits.

Anticipated effectiveness in actual practice:

There would be some sediment losses following timber harvest. Mechanical practices would minimize soil erosion until vegetative cover becomes fully effective.

COST CONSIDERATIONS

Road costs, erosion control measures, replanting, clean-up operations and services of a professional forester are some items to consider in estimating costs.

EXAMPLES

The following is an example of Woodland Protection as required in a timber harvesting permit:

RESUME OF APPLICATION

Approximately 1 million board feet of timber will be harvested from 100 acres of prior cut forest land. The operation will utilize 1 or 2 small tractors, possibly a rubber-tired skidder and logging crew. Approximately 200 feet of truck road, 1/2 mile of skid trail, and two log landings will be constructed. Approximately 3 miles of poorly maintained truck roads will be regraded, and have proper drainage established. Access roads will be reopened for fire trucks and equipment used to manage the tree farm. Gates and fences are being established to control trespass by off-road vehicles. Ten culverts will be installed, two temporary railroad car bridge crossings will be utilized and one permanent railroad car bridge constructed. All of the required preparatory work has been completed and inspected by the Natural Resources Coordinator. The haul route will utilize the County Road to Highway 1, where trucks will go north or south depending on where the timber is marketed.

Special conditions:

1. Rolling dips (a waterbreak spread over 10 to 30 feet) shall be constructed with the reopening of all roads instead of waterbreaks, except where it is clearly not feasible.

2. All trails within reasonable distance of timber harvesting operations shall have water bars installed as if they were skid trails; all water bars shall be cut at least 12".

3. Existing roads and skid roads shall be used whenever possible to minimize new construction and earth moving and best utilize the land for long-term timber production.

4. Where feasible, the berm along the main haul road will be removed by spreading it on the main road to create an out-sloped road surface.

5. Drainage of the constructed skid trail above the slide shall be constructed so that no additional water will be placed on the slide area or above it.

6. Constructed skid trails shall be flagged and the location approved by the NRC prior to felling of timber and in advance of construction. The timber faller shall be made aware of the skid trail location.

7. Mitigation measures described in the Negative Declaration shall be implemented. Slash shall be spread and compacted, straw mulch spread and seeding done as it is necessary to prevent excessive erosion.

REFERENCES

1. Zeberg-Nejedly Forest Practice Act of 1973, Division 4, Chapter 8, Public Resource Code.

2. Soil Conservation Service, "1970 California Soil and Water Conservation Needs Inventory", U. S. Department of Agriculture, Davis, California.

3. Soil Conservation Service, "Field Office Technical Guide", U. S. Department of Agriculture, District Field Office (unpublished).

INSTALLATION COSTS
for
RECOMMENDED CONSERVATION PRACTICES

The following table relates thirteen control measures to their component conservation practices. The same conservation practice may be used in more than one control measure. Estimated unit costs for installation of the recommended practices are given in the table. These costs for the most part are expressed as a range.

It is extremely difficult to determine costs without considering specific sites. Sites requiring control measures can be so different that cost estimates do not always appear to be realistic. The costs in this table were obtained from a number of sources and many reflect such variability.

Some of the cost variation factors are related to the site, types of equipment required and how the practices are installed; whether by formal contract with a large contractor, informal contract with a amall contractor, or landowner installed. For example, the costs of small operators and individual landowners would differ from formal contractors who would have considerably more overhead costs. Some costs can vary because of the differences in bookkeeping methods in arriving at costs.

The unit costs given in this table are guidelines to cost considerations. They do not include engineering and planning costs where these services are required or needed to install the practice. Some facilities require operation and maintenance costs which are not included, as for example irrigation systems and access roads.

Table 4

INSTALLATION COSTS FOR MAJOR CONSERVATION PRACTICES

Conservation Practice	Estimated Costs in Dollars per Unit of Practice: Unit	Estimated Costs in Dollars per Unit of Practice: Cost	CONTROL MEASURES: Conservation Cropping Systems	Conservation Irrigation System	Control Erosion on Construction Sites	Control Roadside Erosion	Critical Area Treatment	Diversion and Ditches	Grade Stabilization Structures	Pasture and Range Management	Runoff and Sediment Control, Ponds and Basins	Streambank and Channel Protection and Stabilization	Waste Management System	Watershed, Wildlife and Recreation Land Improvement	Woodland Protection
Access Road															
Cattle guard, welded steel pipe	Each	$300 - 600			X			X	X			X		X	X
Double lane, asphalt 20' wide	LF	19.50 - 25.00			X			X	X			X		X	X
Double lane, gravel 20' wide	LF	10.50 - 14.00			X			X	X			X		X	X
Single lane, asphalt 10' wide	LF	11.50 - 15.00			X			X	X			X		X	X
Single lane, gravel 10' wide	LF	6.50 - 8.00			X			X	X			X		X	X
Single lane, untreated 10' wide	LF	.90 - 1.50			X			X	X			X		X	X
Clearing and Snagging	Acre	100 - 2,500										X			
Conservation Cropping System	Acre	1.50	X												
Contour Farming	Acre	3.00 - 5.00	X												
Contour Orchard & Other Fruit Areas	Acre	20.00	X												
Cover and Green Manure Crops	Acre	32.00 - 37.00	X		X										
Critical Area Planting	Acre	70 - 500			X	X	X					X		X	X
Crop Residue Use	Acre	3.00 - 6.00	X												
Dam, Diversion	Each	800 - 5,000				X		X	X		X				
Appurtenant structures	Variable					X		X	X		X				
Compacted earthfill	CY	.85 - 2.00				X		X	X		X				
Reinforced concrete	CY	100 - 200				X		X	X		X				

INSTALLATION COSTS FOR MAJOR CONSERVATION PRACTICES

Conservation Practice	Estimated Costs in Dollars per Unit of Practice: Unit	Estimated Costs in Dollars per Unit of Practice: Cost	CONTROL MEASURES: Conservation Cropping Systems	Conservation Irrigation System	Control Erosion on Construction Sites	Control Roadside Erosion	Critical Area Treatment	Diversion and Ditches	Grade Stabilization Structures	Pasture and Range Management	Runoff and Sediment Control, Ponds and Basins	Streambank and Channel Protection and Stabilization	Waste Management System	Watershed, Wildlife and Recreation Land Improvement	Woodland Protection
Debris Basin	Each	500 - 5,000			X		X				X	X	X		
Appurtenant structures	Each	Variable			X		X				X	X	X		
Compacted earthfill	CY	.85 - 2.00			X		X				X	X	X		
Reinforced concrete	CY	35 - 200			X		X				X	X	X		
Deferred Grazing	Acre	6.00								X					
Dike	CY	.75 - 1.75										X	X		
Diversion	CY	.60 - 1.75			X		X				X		X		
Drain System Structure	Each	200 - 2,000											X		
Reinforced concrete or masonry	CY	100 - 200											X		
Emergency Seeding of Burned Areas	Acre	12 - 15								X				X	X
Fencing	Lin.Ft.	1.00 - 2.75				X	X			X			X		X
Fertilizing (Pastureland)	Acre	15 - 25								X					
Fertilizing (Rangeland)	Acre	15 - 20								X					
Firebreak	Lin.Ft.	.20 - .40								X				X	X
Fish Stream Improvement	Lin.Ft.	5.00												X	
Grade Stabilization Structure	Each	Variable			X	X		X	X			X			

INSTALLATION COSTS FOR MAJOR CONSERVATION PRACTICES

Conservation Practice	Unit	Cost	Conservation Cropping Systems	Conservation Irrigation System	Control Erosion on Construction Sites	Control Roadside Erosion	Critical Area Treatment	Diversion and Ditches	Grade Stabilization Structures	Pasture and Range Management	Runoff and Sediment Control, Ponds and Basins	Streambank and Channel Protection and Stabilization	Waste Management System	Watershed, Wildlife and Recreation Land Improvement	Woodland Protection
	Estimated Costs in Dollars per Unit of Practice		CONTROL MEASURES												
Grassed Waterway or Outlet															
Hydroseeding w/ or w/o mulch	Acre	250 - 850			X	X		X		X					
Seeded w/ or w/o mulch	Acre	100 - 750			X	X		X		X					
Sodded	SF	.20 - .50			X	X		X		X					
Heavy Use Area Protection															
Asphalt Paving	SF	.77			X									X	
Gravel surfacing, 6-inch	SF	.25			X									X	
Seeded w/ or w/o mulch	Acre	100 - 750			X									X	
Hillside Ditch	LF	.50 - 1.25			X	X	X	X							X
Irrigation Ditch and Canal Lining															
Concrete, non-reinforced	CY	120 - 160		X											
Prefabricated asphalt plank	SF	.85 - 1.10		X											
Reinforced concrete	CY	150 - 190		X											
Slipform concrete	CY	90 - 125		X											
Irrigation Pipeline															
Asbestos cement 3" - 16"	LF	4.00 - 14.50		X	X	X									

INSTALLATION COSTS FOR MAJOR CONSERVATION PRACTICES

Conservation Practice	Estimated Costs in Dollars per Unit of Practice: Unit	Cost	Conservation Cropping Systems	Conservation Irrigation System	Control Erosion on Construction Sites	Control Roadside Erosion	Critical Area Treatment	Diversion and Ditches	Grade Stabilization Structures	Pasture and Range Management	Runoff and Sediment Control, Ponds and Basins	Streambank and Channel Protection and Stabilization	Waste Management System	Watershed, Wildlife and Recreation Land Improvement	Woodland Protection
			CONTROL MEASURES												
Irrigation Pipeline (continued)															
Cast-in-place concrete 30"	LF	9.00 - 11.00		X	X	X									
" " " " 36"	LF	10.00 - 12.00		X	X	X									
" " " " 42"	LF	11.50 - 13.50		X	X	X									
High pressure underground plastic, 4" - 15"	LF	2.50 - 9.00		X	X	X									
Low pressure underground plastic 4" - 15"	LF	2.50 - 8.00		X	X	X									
Non-reinforced concrete 6" - 30"	LF	4.75 - 18.50		X	X	X									
Steel 4" - 24"	LF	9.00 - 35.00		X	X	X									
Irrigation System, Drip	Acre	500 - 1,200		X		X	X								
Irrigation System, Sprinkler	Acre	400 - 1,200		X	X	X	X								
Irrigation System, Surface and Subsurface	Acre	200 - 650		X											
Irrigation System, Tailwater Recovery	Each	2,000 - 4,000		X											
Irrigation Water Management	Acre	2.00 - 10.00		X	X										
Land Smoothing	Acre	50 - 150			X		X						X		
Lined Waterway or Outlet															
Concrete, non-reinforced	CY	120 - 160			X	X		X	X		X		X		
Reinforced concrete	CY	150 - 190			X	X		X	X		X		X		
Slipform concrete	CY	90 - 150			X	X		X	X		X		X		

INSTALLATION COSTS FOR MAJOR CONSERVATION PRACTICES

Conservation Practice	Estimated Costs in Dollars per Unit of Practice: Unit	Estimated Costs in Dollars per Unit of Practice: Cost	CONTROL MEASURES: Conservation Cropping Systems	Conservation Irrigation System	Control Erosion on Construction Sites	Control Roadside Erosion	Critical Area Treatment	Diversion and Ditches	Grade Stabilization Structures	Pasture and Range Management	Runoff and Sediment Control, Ponds and Basins	Streambank and Channel Protection and Stabilization	Waste Management System	Watershed, Wildlife and Recreation Land Improvement	Woodland Protection
Livestock Exclusion	Lin.Ft.	2.65					X								X
Minimum Tillage	Acre	10.00	X												
Mulching	Acre	500 - 600	X		X	X	X								
Open Channel	CY	1.00 - 2.00			X							X			
Pasture and Hayland Management	Acre	3.00								X					
Pasture and Hayland Planting	Acre	35 - 50								X					
Pipeline, Stockwater and Recreation	LF	.50 - 3.00								X	X			X	
Ponds	Each	500 - 5,000			X				X	X	X	X	X		
Appurtenant structures		Variable			X				X	X	X	X	X		
Compacted earthfill	CY	.85 - 2.00			X				X	X	X	X	X		
Reinforced concrete	CY	85 - 200			X				X	X	X	X	X		
Pond Sealing or Lining															
Bentonite	SF	.05 - .07			X				X		X	X	X		
Flexible membrane	SF	.40 - .60			X				X		X	X	X		
Proper Grazing Use	Acre	3.00								X					X
Range Seeding	Acre	18.00								X					

INSTALLATION COSTS FOR MAJOR CONSERVATION PRACTICES

Conservation Practice	Estimated Costs in Dollars per Unit of Practice		CONTROL MEASURES												
	Unit	Cost	Conservation Cropping Systems	Conservation Irrigation System	Control Erosion on Construction Sites	Control Roadside Erosion	Critical Area Treatment	Diversion and Ditches	Grade Stabilization Structures	Pasture and Range Management	Runoff and Sediment Control, Ponds and Basins	Streambank and Channel Protection and Stabilization	Waste Management System	Watershed, Wildlife and Recreation Land Improvement	Woodland Protection
Recreation Area Improvement	Acre	100												X	
Recreation Land Grading and Shaping	Acre	50 - 150												X	
Recreation Trail and Walkway	SF	.20 - .75												X	
Spring Development	Each	1,000								X					
Streambank Protection	SY	10.00 - 20.00			X							X			
Stream Channel Stabilization		Variable			X							X			
Stubble Mulching	Acre	7.50 - 9.50	X												
Subsurface Drain	LF	.40 - .75											X		
Tree Planting	Acre	400			X	X						X		X	X
Waste Management System	Each	2,500 - 26,000											X		
Waste Storage Pond															
Appurtenant structures		Variable											X		
Compacted earthfill	CY	.85 - 2.00											X		
Pond lining, flexible membrane	SF	.40 - .60											X		
Pond sealing, bentonite	SF	.05 - .07											X		

INSTALLATION COSTS FOR MAJOR CONSERVATION PRACTICES

Conservation Practice	Unit	Cost	Conservation Cropping Systems	Conservation Irrigation System	Control Erosion on Construction Sites	Control Roadside Erosion	Critical Area Treatment	Diversion and Ditches	Grade Stabilization Structures	Pasture and Range Management	Runoff and Sediment Control, Ponds and Basins	Streambank and Channel Protection and Stabilization	Waste Management System	Watershed, Wildlife and Recreation Land Improvement	Woodland Protection
	Estimated Costs in Dollars per Unit of Practice		CONTROL MEASURES												
Waste Storage Structure															
Appurtenances	CY	Variable											X		
Reinforced concrete	CY	100 - 200											X		
Waste Treatment Lagoon															
Appurtenant structures		Variable											X		
Compacted earthfill	CY	.85 - 2.00											X		
Pond lining, flexible membrane	SF	.40 - .60											X		
Pond sealing, bentonite	SF	.05 - .07											X		
Reinforced concrete	CY	100 - 200											X		
Wildlife Upland Habitat Management															
Herbaceous	Acre	Variable by Season												X	
Woody	Acre	Variable by Season												X	
Wildlife Watering Facility															
Surface area spring 1,500 sq. ft.	Each	1,000 - 1,500												X	
Woodland Improved Harvesting	Acre	500 - 750													X
Woodland Improvement	Acre	200 - 250													X
Woodland Site Preparation	Acre	60 - 75													X